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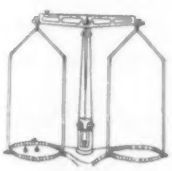

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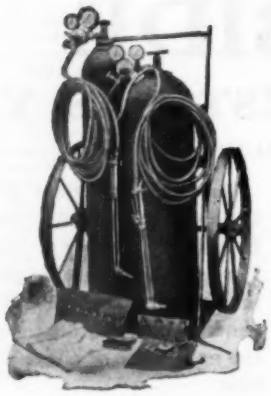

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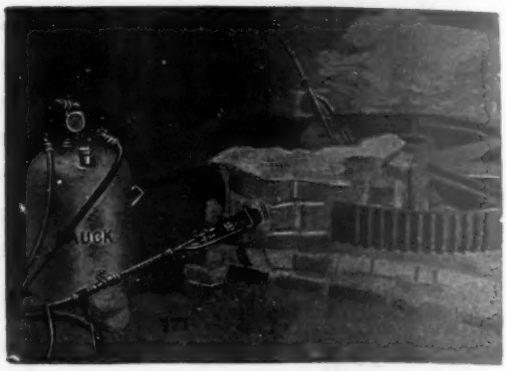

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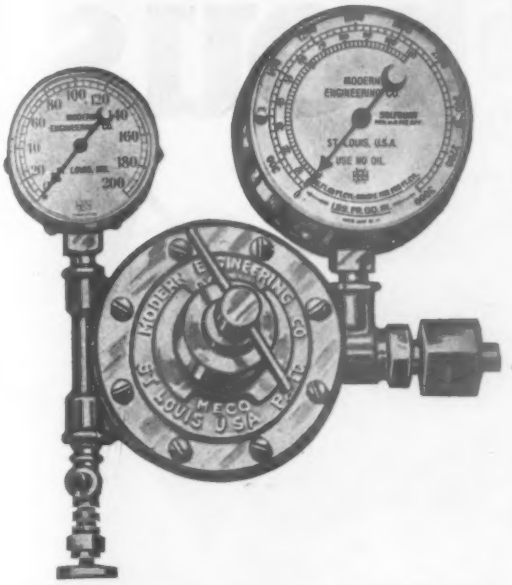

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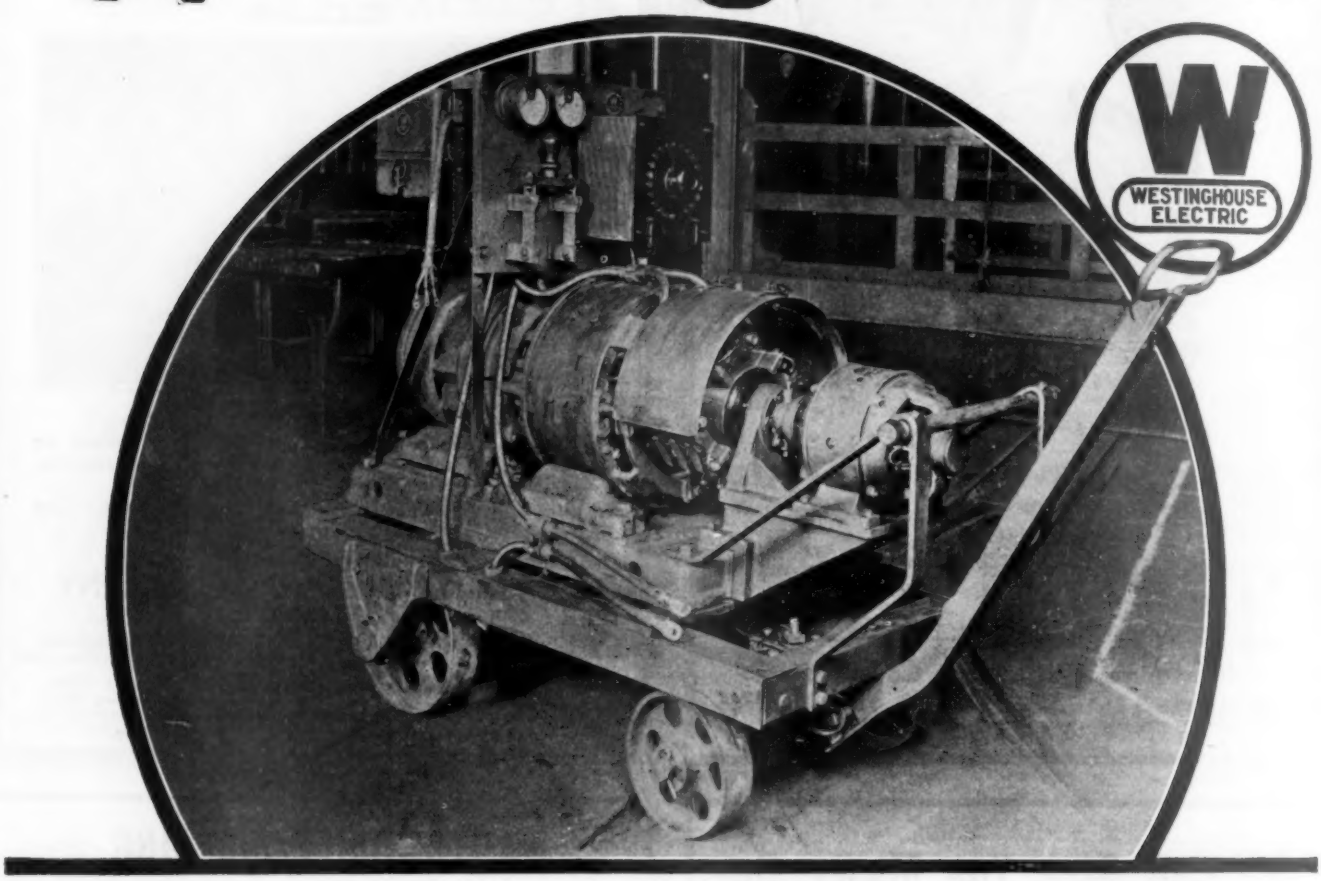

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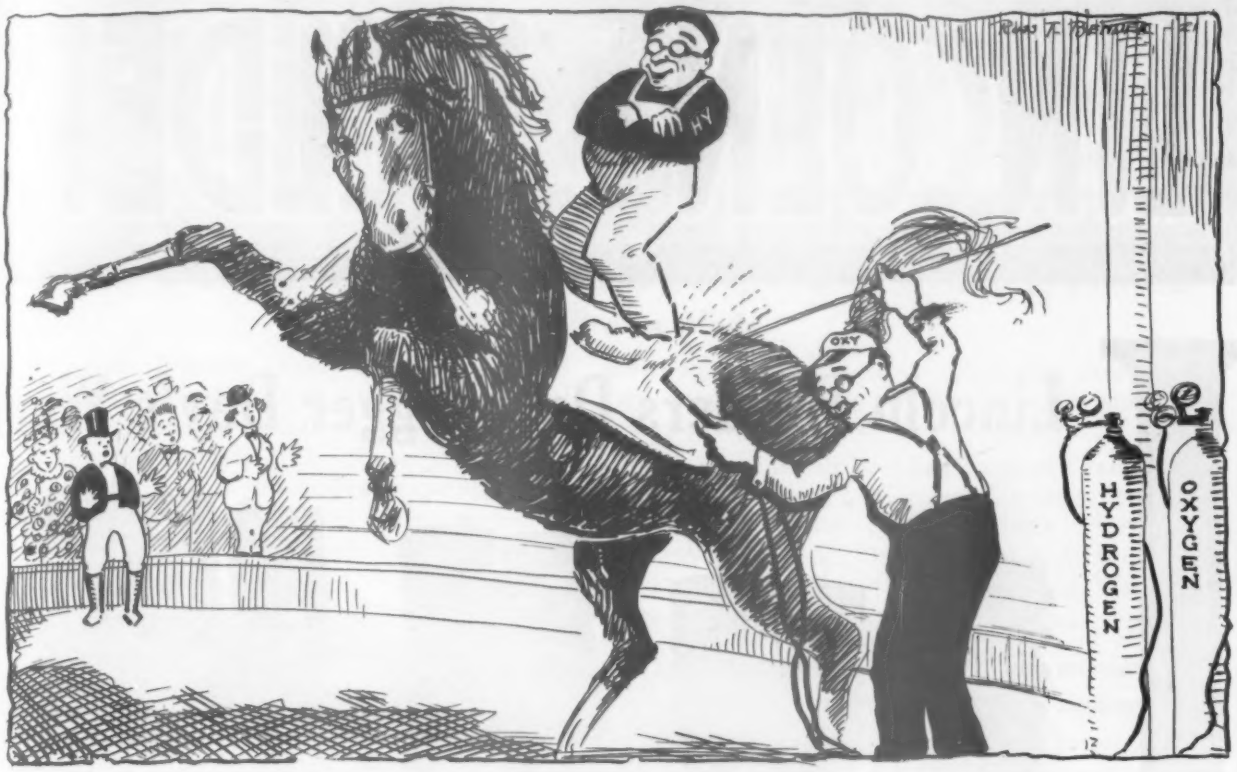

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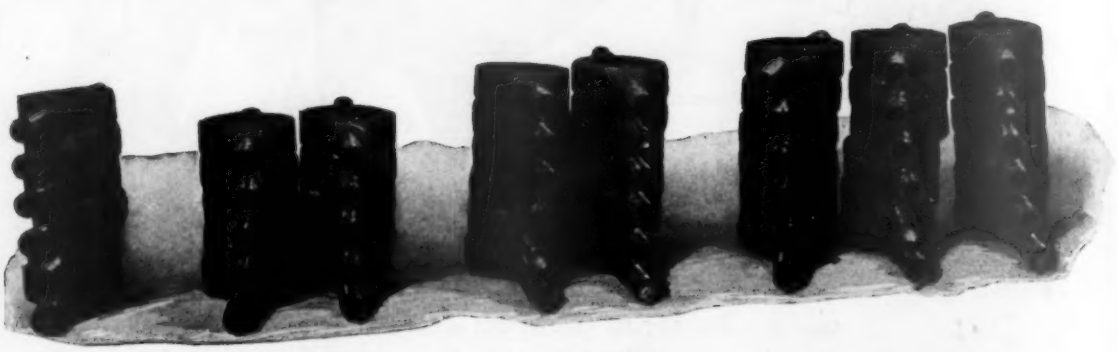

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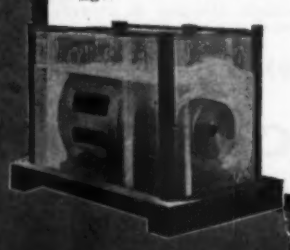

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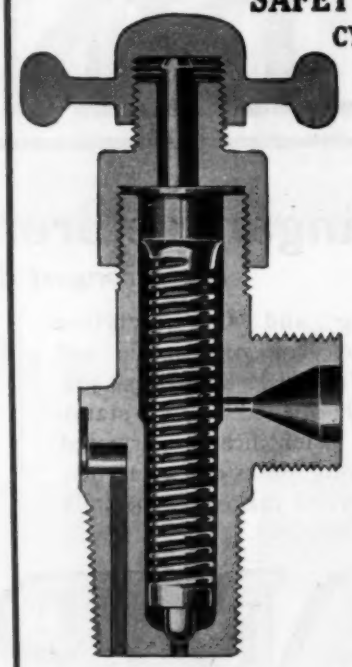

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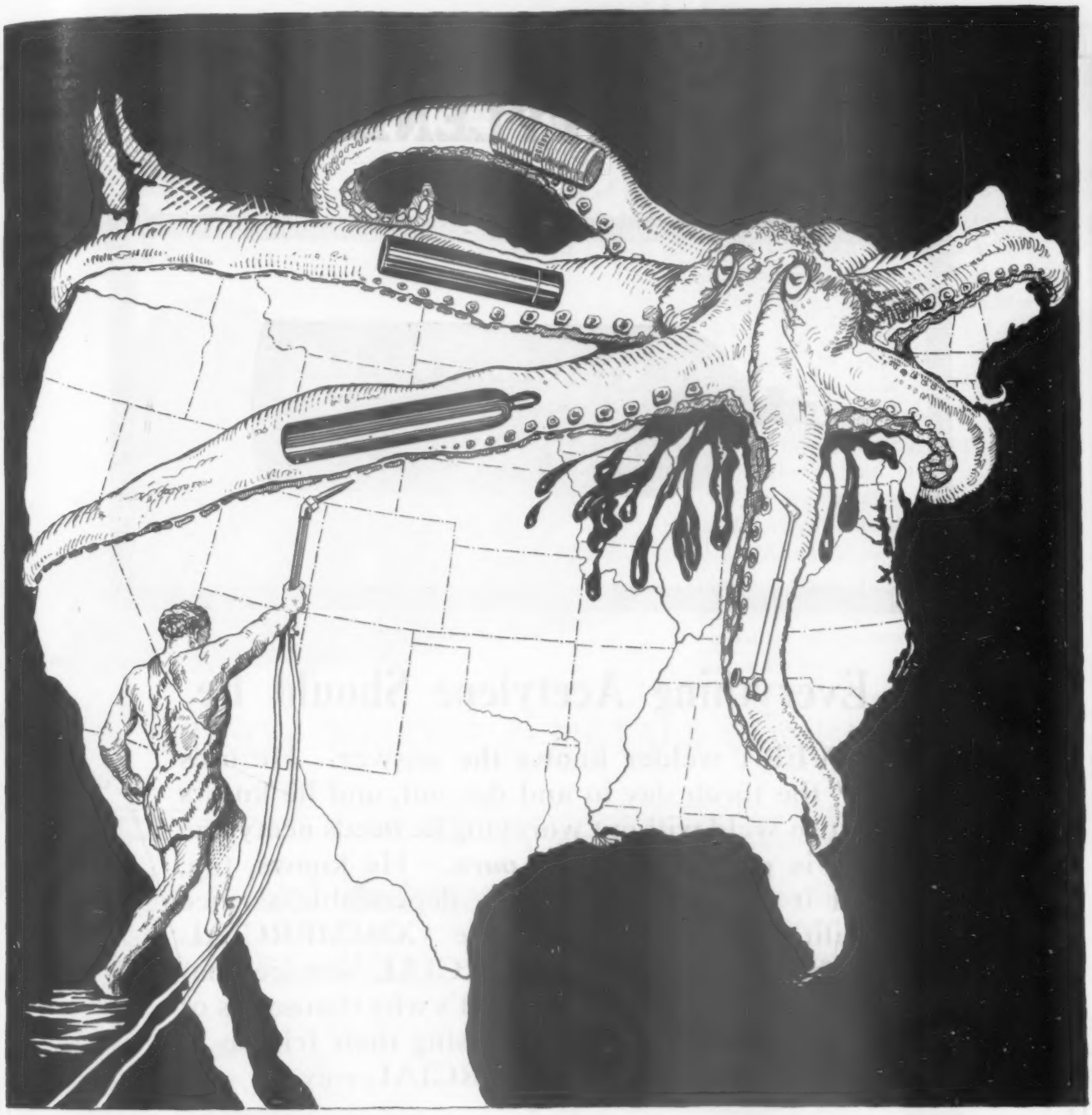

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WELDING RAIL JOINTS

A Discussion of the Work Done on Street Railways by the Lincoln Process

NO OTHER single operation is performed by the welding department of the street railway in such volume as the making of a rail joint. Whenever new track is laid the engineer has to select a joint which, under the given conditions, will promise maximum durability and economy in service, and when it is a question of repairing broken joints he must also look to the matter of doing the job with as little interruption to the traffic as possible. Before the various welding processes were well developed joints were bolted or riveted, but there are now several methods of producing welded joints which admittedly add to the life of the rail by making it one continuous piece. The perfecting of these processes and the training of operators to observe the best practices are two tasks that will have as their common result the saving of thousands of dollars annually in maintenance costs.

The Lincoln process of welding joints will be taken as an example, and this article will describe the process in detail, showing how it is applied under normal conditions, and how some modifications of it are made to serve a useful purpose. Briefly stated, the process consists of welding plates to the

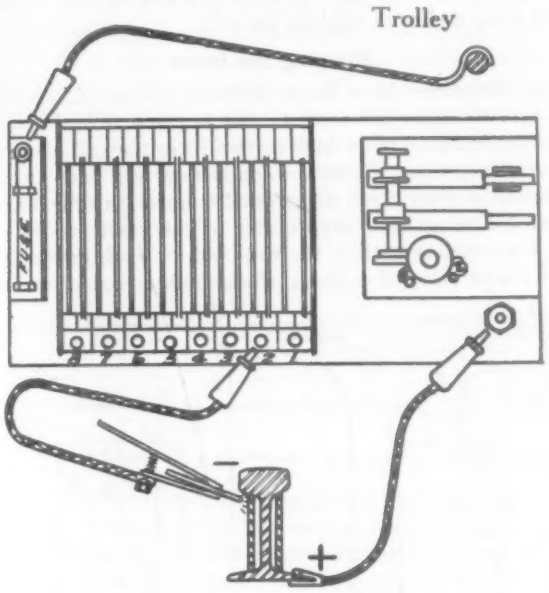


Fig. 1. Diagram of Connections.

ball and base of the rail by the carbon arc, the filler rod being laid in the groove of the seam instead of fed by hand as in repair work. A dynamotor, equipped with suitable surge control for protection against line fluctuations caused by the starting and stopping of cars, takes the current from the trolley, as shown in Figure 1, and supplies the proper welding current through the arc. The trolley cable is a light cable supplied with a plug on one end and a trolley hook on the other end. A convenient trolley hook pole can be made by fastening the trolley cable to a long bamboo pole or any suitable pole of strong wood. The trolley hook should be taped on with its back to the pole, and should be kept bright and clean at all times. The ground clamp can be replaced by a heavy weight placed on top of the rail, provided both are clean and smooth. This substitution is particularly useful where repairs are made on old work, because the old rails are so scaly that the best contact surface is on the top.

Details of Operation

Specially constructed apparatus has been developed for this process, and the method of operation has been worked out in detail. Figure 2 shows the essential details of welding a joint on a groove rail. We have illustrated here the rail, the plates, the filler rod, with flux, the carbon electrode, and the copper "defining bar." This defining bar serves an important purpose, and will be treated more fully later. Note the recommendation that the base seams be welded before welding the head seams, that the edge of the defining bar fit snugly against the rail, not more than $\frac{1}{16}$ inch from the rod, that the filler rod must lie flat against the welding line, that the rod be evenly covered with flux, and that the welding handle be held so as to maintain a definite angle with the carbon electrode. Before running the seam it is good practice to tack the rod lightly at both ends and in the middle by touching it with the arc. In the diagram bolts are indicated with light lines. On new work the plates are bolted to the rail for the purpose of making a strong "set-up," and are removed after the weld is completed. When making reclaim joints it is common practice to leave the bolts in place, and weld the nut to the bolt after finishing the seams. Care should be taken to see that the

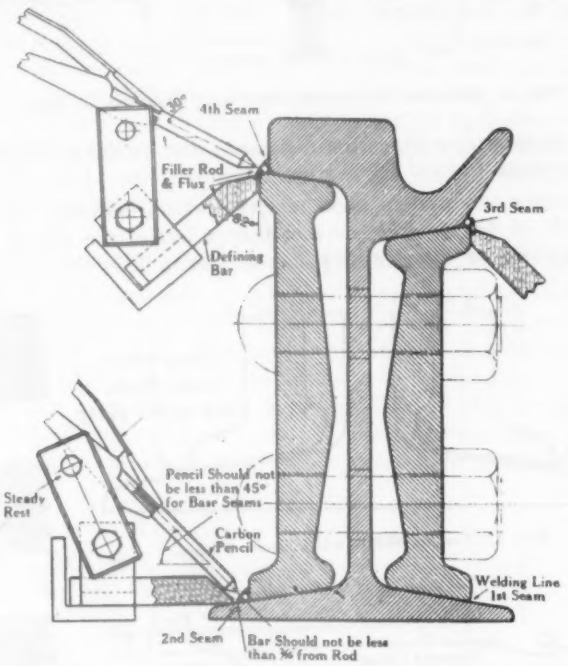


Fig. 2. Proper Set-up for Welding Rail Joints

space between the filler rod and the edge of the defining bar is the same for the full length of the bar.

When welding in paved streets it is necessary to make a sufficient excavation so that the welder can work comfortably. Two stones beyond each end of the plates, as shown in Figure 3, gives enough working space in length, and a twenty-inch space on each side of the rail will leave ample room. In this sketch there is indicated the use of a small jack for holding the plate in place for welding, a convenient device in case bolting is impracticable.

Preparing the Work

It is one of the primary principles of fusion welding that the perfection of the finished weld depends to a large degree on the preparation of the materials, and although the rail joint is a highly specialized type of weld, allowing the operator to deviate from some of the rigid rules of repair welding, preparing the joint must be done correctly to secure the results that

are sought. The process has been developed with a view to making a sufficiently strong joint at maximum welding speed, but this strength will not be secured if any essential detail of operation is slighted. It should therefore be noted that one of the first things called for is a good mechanical joint between the plate and the rail before the welding is started. Warped or canted plates do not furnish such a joint. The former must be hammered straight before starting to put them in place, and the latter should be made to fit straightly and snugly by the use of shims, as shown in Figure 4. Impact tests have indicated that "short" plates set in with shims

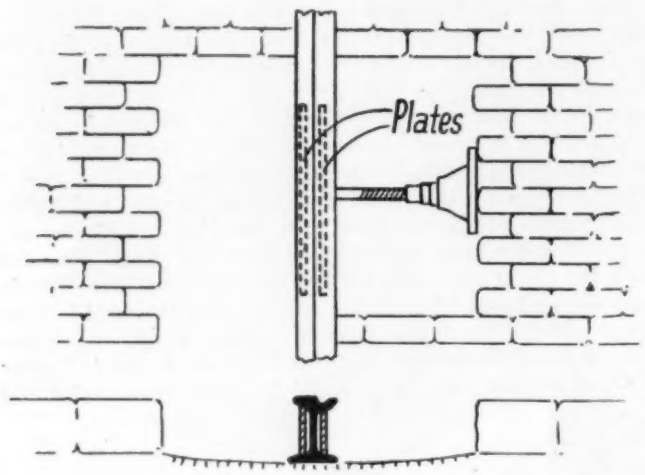


Fig. 3. Showing Excavation Necessary and Use of Jack.

have at least four times the resistance that similar plates have when made to "fit" by canting them.

Another essential to good results is clean material. Every particle of dirt or scale or rust that is left in the line of the weld works an injury to the joint. The welder who attempts

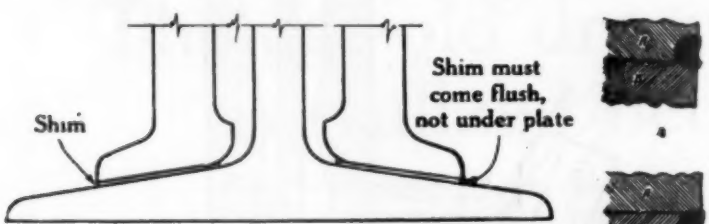


Fig. 4. Use of Shims with Short Plates.

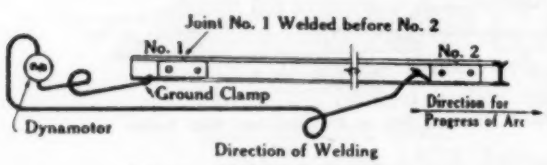


Fig. 6. Direction of Welding.

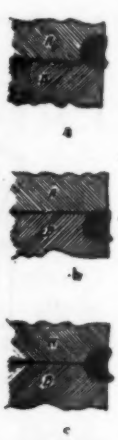


Fig. 5.

to work on dirty stock can tell by the way his arc behaves that the metal is not fusing evenly, and this indication is readily confirmed by sawing through a test specimen. Microscopic examination is not necessary to show the effect.

Maximum durability will not be secured if there is a gap left between the rail ends. If they cannot be made to butt snugly, it is worth while to drive in an insert to completely fill the space. The rails should be firmly imbedded in their proper place on the subgrade, not jacked up to a point where they are out of surface alignment.

The Defining Bar

As reference has been made to that part of the apparatus called the defining bar, it is well to note the reasons for using this device. First of all, it has the effect of confining and directing the arc. In Figure 5, (a) shows a weld made with the bar set too high, (b) shows a weld made with the setting too low, and (c) shows a weld made with the bar set so as to direct the arc exactly in the center of the welding line, giving a joint of maximum strength. The bar also serves to hold the filler rod and flux in place and to put the molten metal where it belongs. And if it is cold when the welding starts it concentrates the welding heat in the line of the weld and by conducting heat from the welding area tends to prevent excessive heating of the rail. The bar is largely responsible for the success of the apparatus in making satisfactory joints rapidly. Its share of the operation is not spectacular but it is none the less important. It will work at its best when kept clean, straight, and cold. Oxides form on the edge very

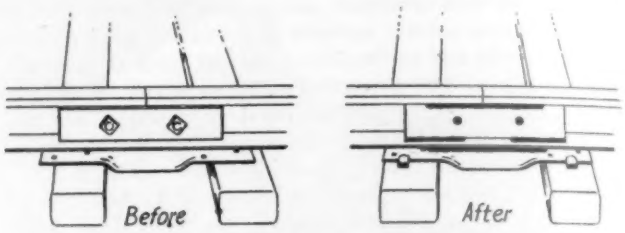


Fig. 7. Abbot Joint in Place, and Finished Joint.

quickly, and when heated it soon becomes dented and scarred. Constant care is necessary to keep it clean enough so that it will fit snug and true against the rail.

Running the Seam

After the parts have been properly prepared, everything "set," and the filler rod tack-welded in place at both ends, the welder strikes his arc an inch or two from the end of the plate nearest the ground clamp or connection and runs the seam in a direction away from the ground connection (Fig. 6), being careful not to make a deep crater at the start (which would leave a weakening nick in the rail) but to work gradually into a crater and carry the crater along uninterruptedly until the

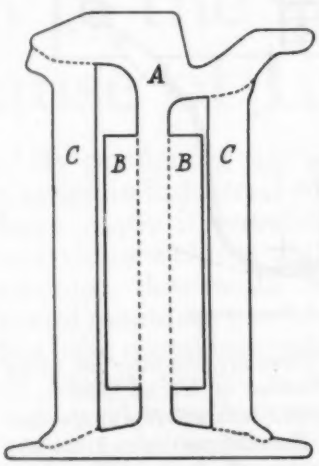


Fig. 8. Repair of Old Joint Broken Through Weld.

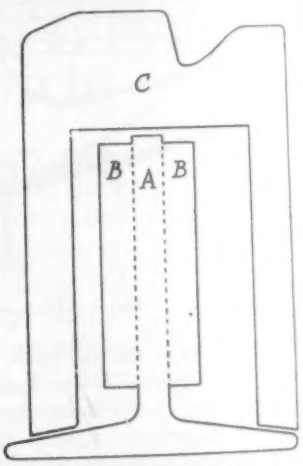


Fig. 9. Temporary Repair Where Ball of Rail is Broken Off.

end of the seam is nearly reached, then gradually lengthening the arc so as to finish the seam smoothly without a pit or nick in the rail. He forces the metal upward into the weld by pointing the arc slightly below the center of the filler rod, and maintains an arc length that allows the metal to flow smoothly in the crater without bubbling. If there is a space between the rail ends at the base he skips an inch or two in the center of the bottom seam, but does not allow a continuous seam to be interrupted if he can possibly help it.

Organizing the Work

Economy in welding rail joints is best secured by careful organization of the work, not by attempting to crowd the

apparatus and the operator to full capacity or more than capacity. It is apparent to anyone familiar with fusion welds that thorough penetration is not secured in this particular process. The fact that such failures as have occurred in service are practically all outside the weld shows that thorough penetration is not necessary. It is necessary, however, that the seam be made as strong as possible throughout its depth, and this is accomplished only by careful, deliberate work. The welder can work at his best when he is supplied with enough help so that he can give all his attention to manipulating the arc. The details of excavation, setting up, transporting apparatus,

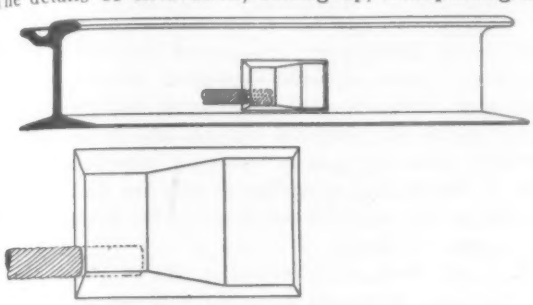


Fig. 11. Welding Cable to Rail.

grinding the rails, keeping the bars clean, etc., are taken care of by unskilled laborers.

The Abbott Joint

In localities where rails are subjected to extreme changes of temperature or extremely heavy traffic, a certain percentage of broken joints is almost inevitable. The type of joint described above has given good satisfaction on some of the largest railway lines in the United States, yet there have been some breaks. These breaks have been found to occur outside of the weld, but near it, and consequently they have been ascribed to the heat effect of the welding operation at the top and bottom of the rail acting like nicks in the rail at these points, re-

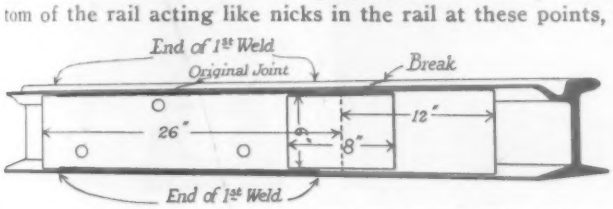


Fig. 10. Repair of Rail Broken Near Seam Welded Joint.

sulting in a break through the weakened line. The fact that the rail and the plates together are made to form a very rigid section adjoining the weakened area helps to locate the break near the end of the seam. A device known as the "Abbott Joint" is being employed in the city of Baltimore to overcome this condition. Figure 7 shows how the joint is made. Here use is made of a base plate inserted under the joint and resting on ties on either side. The head seam is only sixteen inches long, leaving four or five inches unwelded at each end. Two eight inch welds are made at the ends of the base seams, leaving a six or eight inch gap in the center and one-inch lengths at the extreme ends of those seams unwelded. Then the base of the rail is welded to the base plate, a sixteen-inch seam in the center of the joint. This method is said to give a better distribution of the strains and also provide greater flexibility of the rail at the joint.

Reclamation Work

The Lincoln process is being used extensively by the Chicago Surface Lines for the reclamation of broken joints. Practically all the track in this system is laid in paved streets, and all of it carries heavy traffic. Some two hundred thousand joints have been made by spot welding heavy fish plates to the web of the rail at the joint, and many such joints have been in service for long periods. The breaks that occur are of two sorts. Very rarely the break is found through the weld. In such cases a repair is easily accomplished by seam welding new plates to the head and base of the rail, outside the old joint. Figure 8 shows a cross section view of such a repair. More often it is the case that the ball of the rail is torn off the web for a short distance. A temporary repair is made by laying a "dutchman" over the break, as shown in Figure 9. This has a heavy cross section and is firmly supported by the base, but it is only an emergency device. As soon as possible a good repair is made by making a "cut-in," i. e., the old rail is cut and a ten-foot section inserted, so the repair really consists of making two new joints.

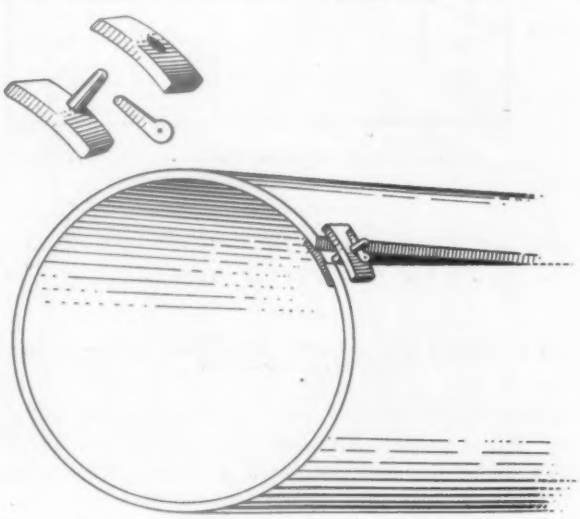
In Figure 10 is illustrated one method used for the reclamation of seam welded joints. A twelve-inch plate abutting the old plate is welded to the head and base of the rail, a second plate 8x6x¾ inches is welded over the seam between the old and the new plates, and a twenty-four inch plate is inserted under the rail, so placed as to support both the old and the new joints.

While these repairs are being made the working parties often pass over sections of the line where it is desired to renew the joint between cable and rail at crossings and switches. A neat and permanent job can be done by using carbon blocks to build a mould around the end of the cable and melting in scrap copper in the form shown in Figure 11. The sketch shows the shape of the mould and the position of the cable when fastened to the rail by welding.

All this welding can be done "under the traffic" without difficulty even in the daytime. Where breaks are not too far apart it is not uncommon for a single welder to complete about thirty joints in an eight hour day without rushing, though doing the work at this rate requires a good sized crew. Moreover, speed is not the only consideration. A first class welder can be trusted to work at the rate best suited to satisfactory results, and "satisfactory results" means welds that will stand up under a real service test.

CONVENIENT DEVICE FOR SHEET METAL WORK

Several devices have already been recommended for lining up sheets or tube shapes preparatory to welding. The one illustrated here is in use in a good many shops and gives good results, notably on tube shapes where it is indispensable that the edges are not subject to any spreading. The sketch shows clearly that the device is a simple one. It consists of two plates of the same curvature as the tube, one of which carries a shank with



a hole in the top for the insertion of a cotter pin. These are placed along the seam according to the length of the weld. The thickness of the shank should be as small as possible. The device is especially useful for odd jobs for which it is impractical to make special jigs. It has been employed very successfully for lining up seam welds in large aluminum containers.—Revue de la Soudure Autogene.

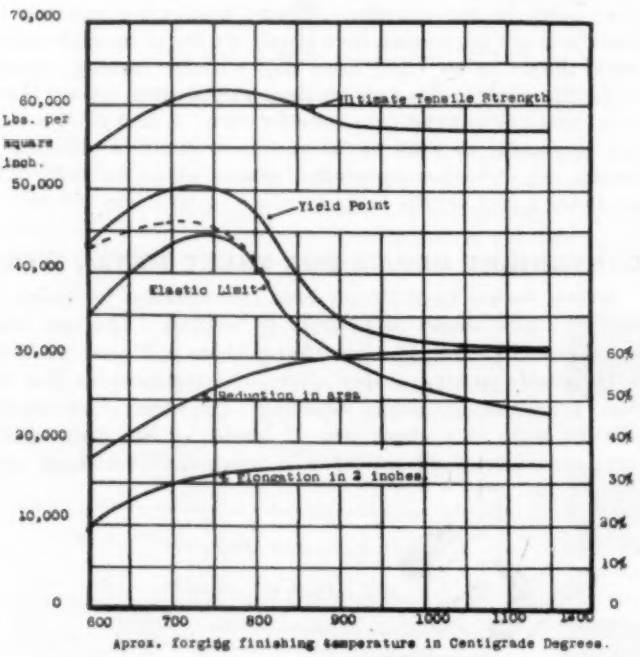
FORGING OF ARC DEPOSITED METAL AND ARC WELDS

Effect on Strength, Ductility and Resistance to "Fatigue"—Forged Joint Stronger Than Base Metal—Forged Alloy Steel Welds—Evolution of the 132,445 Pound Weld

By O. H. Escholz*

"DOES forging improve the physical properties of arc deposited metal?" This question is frequently asked in discussions of weld characteristics and welding processes. Many engineers and supervisors are of the opinion that the metal is non-forgable, being, in their estimation, "hot short." Others are frankly skeptical of the possibility of improving a material reputed to contain large quantities of "nitride needles" with a generous distribution of oxide globules and films, slag and gas pockets, fissures, slip bands, twinning, dendritic structures and such other micrographical defects that a critical examination may reveal.

It is conceded, and now generally recognized, that arc deposited metal is essentially a casting. While theories of deposition phenomena** are still somewhat at variance, quite satisfactory evidence is available, indicating that the complete deposit consists of an aggregate of fused globules. When employing ⅛ in. diameter bare mild carbon content, steel electrodes, complying with the welding wire specifications of the American Welding Society, with a 150 ampere arc current, it is estimated that about 30,000 globules are transferred from the wire electrode for every pound of metal deposited. Since this method of deposition is unique in welding processes and therefore presents opportunities for structural changes and inclusions differing from those occurring in large masses, a quite thorough study was made of the physical properties of *cast* arc deposited metal and reported by the writer on pages 250 to 255 of the February 15th, 1921, issue of Power.



Curve 1

Effect of forging and finishing temperature on Arc Deposited Low Carbon Metal.

Curve 1.

Effect of Forging and Finishing Temperature on Arc Deposited Low Carbon Metal.

In Table I are given characteristic results of tensile tests on standard 2 in. test pieces cut from large blocks of arc metal. This metal was formed by depositing the material in parallel layers, Figure 1-A. The direction of stress was parallel to the direction of layer deposition. The results of the test are indicative of the properties obtainable with skillful manipulation and correct procedure. The U. T. S. of 56,800 and reduction of area of 27 per cent compare favorably with similar criteria for high grade low carbon cast steel. In Figure 2 is shown the ragged, angular or fibrous fractures obtained on tests recorded in Table I.

(a) (b)

Fig. 1. Built up Blocks of Arc Deposited Metal.
(a) Test Block for Stressing Metal Parallel to Direction of Deposition.
(b) Test Blocks Permitting Stressing Metal at Right Angles (or Axially) to Direction of Deposition.

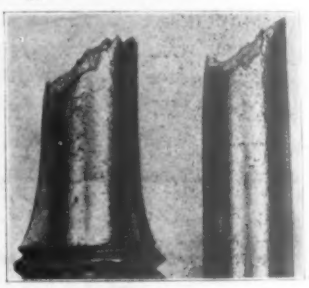


Fig. 2. Ragged, Angular Fibrous Structure of Test Pieces Pulled from Block Shown in Fig. 1-a, Characteristic of the Best Low Carbon Cast Metal.

TABLE I

Tensile Properties of Untreated Arc Deposited Metal

(Stressed in direction of layer deposition)

	Pounds Per Square Inch			Per cent	Per cent
	U. T. S.	Yield Point	Elas. Limit	Elon. in 2 in.	Red. of Area
	56,100	33,400	27,500	18.1	30.8
	56,075	35,875	29,000	16.0	23.4
	58,225	.....	.....	18.0	27.8
Avg.	56,800	34,630	28,250	17.4	27.3

Figure 1-B illustrates a block of arc deposited metal built to a height of 9 in. on a base 3 in. square by super-posing tiers of parallel arc deposited layers. Owing to the difficulty of forming such a structure and the necessity for frequently interrupting and starting the arc, a most favorable opportunity was presented for securing indifferent fusion with high inclusion of impurities. Test pieces were cut parallel to the vertical axis of the block.

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**Phenomena of Arc Welding, O. H. Eschholz, American Electrochemical Society, April, 1921.

Each fused surface between layers on test was therefore subjected to a direct tensional stress. Test results on the cast material are given in the first part of Table II. It will be noted that the U. T. S. and reduction of area average respectively 42,187 and 11.4 per cent. This reduction in strength and ductility from that given in Table I is attributed to incomplete fusion,

TABLE II

Tensile Properties of Inferior Arc Deposited Metal

(Material stressed axially to direction of layer tiers, Fig. 1-B)

	Pounds Per Square Inch			Per cent	Per cent
	U. T. S.	Yield Point	Elas. Limit	Elon. in 2 in.	Red. of Area
Before Forging					
	40,875	29,400	24,250	4.4	15.9
	43,500	28,900	20,000	4.9	7.0
Avg.	42,187	29,125	22,125	4.6	11.4
After Forging					
	56,625	31,500	28,500	27.7	59.1
	57,175	31,675	27,500	27.6	60.1
Avg.	56,900	31,600	28,000	27.6	59.5

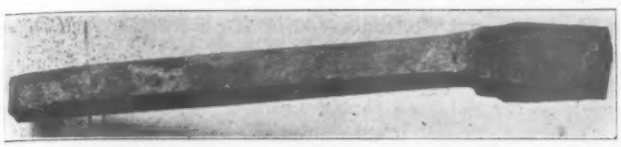

Fig. 3. Forged Arc Metal from Material in Deposit Shown in Fig. 1-b, Section Reduced from 1½x1½ in. to 1x1 in.

oxide inclusions as well as stressing the material in the direction wherein these faults weaken it the most.

Forged Arc Metal

To determine the effect of forging on the properties of an inferior metal, the remaining section of this block (Fig. 1-B) was heated in a smith's forge to a white heat, approximately 1,200°C, and forged on a steam hammer from a 1½x1½ in. section to approximately 1x1 in, as shown in Figure 3, and allowed to cool in air. The results of the tensile tests on specimens cut from the forging are given in Table II. In Figure IV, characteristic fractures are shown of test specimens taken from the

TABLE III

Tensile Properties of Forged Arc Metal

(Stressed in direction of layer deposition)

Test No.	Forging Temp.* "A"	Forging Temp.* "B"	Area of Forging**	U. T. S.	Yield Point	Elas. Limit	% Elon. in 2"	% Red. of Area	Pounds per Sq. In.
1.	954°C (1747°F)	600°C (1110°F)	29%	54,825	43,000	35,000	19.1	36.3	
2.	874°C (1605°F)	750°C (1380°F)	59%	62,175	50,000	44,500	31.3	50.0	
3	1172°C (2146°F)	900°C (1650°F)	34%	57,650	34,800	30,000	33.0	59.1	
4.	1172°C (2146°F)	900°C (1650°F)	53%	56,750	34,650	29,000	36.4	63.5	
5.	1316°C (2400°F)	1150°C (2100°F)	38%	58,875	30,875	25,000	32.7	59.8	
6.	1316°C (2400°F)	1150°C (2100°F)	26.7%	58,700	32,000	21,000	35.2	62.3	

**"A," Before forging, by Pyrometer. "B," After forging, estimated. **Area of forged section in per cent of original unforged section.*

unforged and forged material, reported in Table II. It will be observed that the forging operation has increased the U. T. S. from 42,187 to 56,900 lbs. per square inch and the reduction of area from 11.4 to 59.5 per cent.

To examine forged arc metal more critically, three blocks of deposited metal were prepared by building up tiers of parallel layers similar to the exhibit shown in Figure 1-A. Upon trimming off the base plate and sides, each completed deposit approximated 1½x1¾x5 in. Half of each block was forged to size at one time, on a Bradley hammer, giving the six heats reported in Table III. The fractures obtained on the standard 2 in. tensile test pieces are shown in Figure 5. Examination of this data shows that:

(1) Arc Metal is forgable over the following approximate temperature range: 750°C (1,380°F) to 1,316°C (2,400°F).

Fig. 4. Character of Fracture of Material Before and After Forging Reported in Table II.
Upper, Before Forging—U. T. S.—43,500 lbs. sq. in. % Red. in Area 7% Square Fracture.
Lower, After Forging—U. T. S.—57,175 lbs. sq. in. % Red. in Area 60.1% Cup Fracture.

(2) Forging imparts a consistent high ultimate tensile strength, of the order of 58,000 pounds per square inch, to low carbon deposits.

(3) If the forging operation is continued to a red heat the elastic limit may be practically doubled. (As the lower forging temperature limit is reduced from that in Test No. 6 to that in Test No. 2 it will be noted the elastic limit is increased from 21,000 to 44,500 pounds per square inch.)

(4) Forging increases the ductility of arc metal, the elongation exceeding 30 per cent and the reduction in area exceeding 50 per cent.

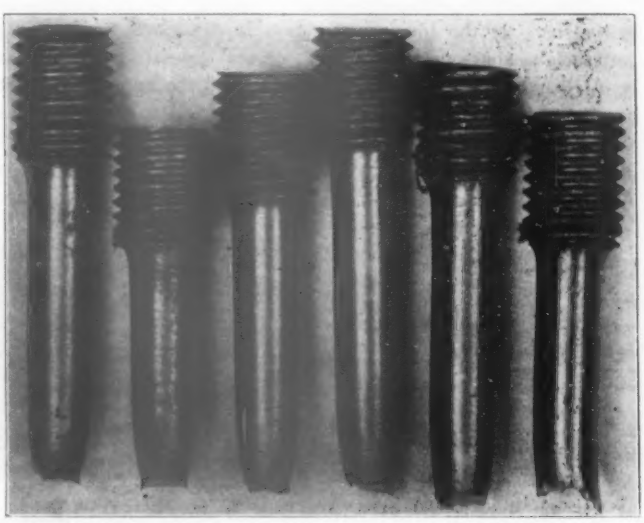

Fig. 5. Cup Shaped Fractures Secured on the Two Forged Specimens of Arc Deposited Metal Reported in Table III. (No. 1 of Table Shown at Right. Others in Sequence.)

The forging operation in the case of test specimen No. 1 produced too great a reduction of section below a proper working heat, resulting in tearing the metal in a longitudinal direc-

**Bradley Stoughton: The Metallury of Iron and Steel.*

tion and thereby lowering its resistance to stress as well as decreasing its ductility.

The increased strength and ductility obtained by the forging operation* may be attributed to

Fig. 6-(a)

Fig. 6-(b)

Micrographs of Forged Sections from Test Specimens No. 6 (a) and No. 2 (b), Table III Showing Reductions in Grain Size Upon Decreasing Forging Temperature.

(1) Refinement of crystal size. The forging pressure crushes the grains, mixes them intimately and shortens the cleavage planes in the direction of impact along which the structure tends to yield, thereby increasing the strength of the metal. The finishing temperature of forging also influences the ultimate grain size. If the forging operation is continued to a temperature below approximately 750°C, crystal growth will not occur on further cooling and the metal will retain the improved physical properties characteristic of forged material. If the forging ceases at a higher temperature crystal growth will occur while the metal is cooling to approximately 750°C, thereby losing some of the advantages that may be derived from forging. The data shown in Table III and plotted in Curve No. 1 illustrates this very well. With reference to Curve No. 1, it should be noted that higher values would have been obtained for the stress curves between finishing temperatures of 600°C and 750°C if the rate of reduction of section during forging had been reduced. With favorable forging conditions the elastic limit curve in this range would presumably approximate that shown by the dotted line. The correct forging procedure requires the greater part of the reduction in section to be achieved above 750°C, subsequent impacts on cooling further being heavy enough to cause slight deformation only, retaining thereby small crystal size without danger of producing excessive internal strains.

(2) Closing up and possibly welding of gas pockets, etc.

(3) The kneading operation of hammer forging breaks up slag lines, areas of segregation and other heterogenous conditions, distributes impurities and increases the density as well as hardness of the metal.

Micrographs shown in Figure 6 A and B illustrate the effect on the size of crystals and dispersion of impurities on forging at a high temperature, Test No. 6, and a low temperature, Test No. 2.

Forged Arc Welds

The above results show the possibility of improving arc metal by forging. To determine whether the properties of arc welds are also improved under the inevitable conditions of irregular heating and working occurring in practice, as well as small reduction in section, a number of ½x2 in. open hearth mild carbon steel bars having an average U. T. S. of 50,050 pounds per square inch were welded employing a 60° vee, $\frac{3}{32}$ in. diameter mild carbon steel electrodes, 150 or 175 arc amperes and leaving a welt for forging of from ⅛ in. to $\frac{3}{16}$ in.

(A) Weld heated to approximately 1,200°C (2,200°F) in smith's forge and hand forged on anvil. Ultimate strength, after grinding off excess metal, 53,100 lbs. per square inch, failure occurring in *base or parent metal* 1½ in. from weld. Elongation in 1 in. across *unfractured* metal of weld 9.9 per cent. This weld is shown in Figure VII. It will be noted that the joint is stronger than the metal on either side.

Fracture in Parent Metal. Forged Weld. Elongation of Parent Metal.

Fig. 7. Forged Arc Weld (A) Stronger Than Material on Either Side. Parent Metal Failed at 53,100 lbs. Per sq. in. Unfractured Arc Deposited Metal Elongated 10%

(B) Weld heated as in A, but forged on steam hammer, failed *outside of weld* at U. T. S. of 50,050 lbs. per square inch, after grinding off excess metal..

Failure. Weld.

Fig. 8. Machined, Forged, Arc Weld G, Stronger Tran Parent Metal. Stock Failed at 50,200 lbs. per sq. in., Elongation in Unfractured Arc Metal, 9.5%.

(C) Weld heated to approximately 1,200°C (2,200°F) by the *carbon arc,* forged with small hand hammer and ground flush with stock. Failure occurred in *base metal* at U. T. S. of 47,500 lbs. per square inch, elongation in 1 in. of unfractured deposited metal, 6 per cent.

(D) Weld heated and forged as in "C," joint and shank

material machined to 0.425x1.825 in. Specimen failed *outside* of weld at U. T. S. of 51,900 lbs. per square inch; elongation in 1 in. of *unfractured* weld, 6 per cent.

(E) Weld heated and forged as in "C," machined to 0.415x 1.73 in. failed in weld at U. T. S. of 45,200 lbs. per square inch, due to presence of large oxidized area. Elongation in 1 in.

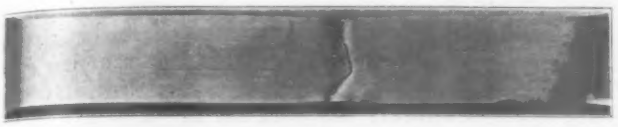

Fig. 9. Weld L, Alloy Steel Base Metal, Nickel Steel, Coated Electrodes, U. T. S. 107,253 lbs. per sq. in., Elongation 14.4% Across Fracture.

at fractured section 20 *per cent, showing ductility of forged arc metal.*

(F) Weld heated and forged as in "C," machined to 0.4x 1.825 in. failed *outside* of weld at 53,000 lbs. per square inch, elongation in 1 in. across unfratured deposited metal, 8 per cent

(G) Weld heated to 1,000°C (1,830°F) in an electric furnace, forged with small hand hammer, machined to 0.305x1.77 in., failed 3 in. beyond weld at U. T. S. of 50,200 lbs. per square inch. Elongation in unfractured arc deposited metal, 9.5 per cent. This weld and the position of failure are shown in Figure VIII.

These tests show that it is possible to obtain, by forging, a weld stronger than the original material, when such material is

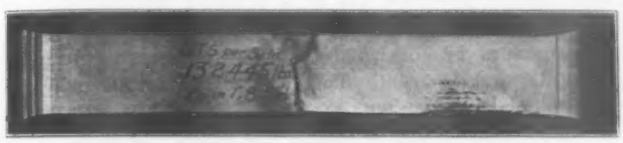

Fig. 10. Weld "M," Same as "L," Except Base Electrodes, U. T. S. 132,445 lbs. per sq. in., Elongation 8.5%.

the ordinary grade of mild carbon open hearth steel. Since it is not general practice to remove the excess metal at the weld, the welts ordinarily employed will assure a generous margin in strength over that of the adjacent base metal. The greater strength of the weld is attributed to the kneading action of the hammer forging process, since rolling of plates serves to maintain slag lines, segregation of impurities, etc.

Forged Alloy Steel Welds

In view of the fact that arc welding is rapidly being extended to the welding of medium carbon and alloy steels, the following welds were made to determine the breadth of application of the forging process:

(H) Axle steel shafting having a diameter of 1⅜ in. and a carbon content of approximately .4 per cent was forged to a section of ½x1½ in. to provide material for weld shanks. A 60° vee cut in this material was welded with a ⅛ in. diameter mild carbon steel at 175 amperes. The *unforged,* machined weld failed at a U. T. S. of 67,850 lbs. per square inch with an elongation in 1 in. of *9 per cent.*

(I) Welded axle steel bars, prepared as in "H," was hand forged on anvil after heating to approximately 1,200°C (2,200°F) machined and failed in the weld at a U. T. S. of *72,500* lbs. per square inch with an elongation in 1 in. of *23 per cent.* This result again indicates that forging increases the strength and ductility of arc welds.

(J) Axle steel prepared as in "H," but welded with ⅛ in. diameter 3½ per cent nickel steel and hand forged on anvil failed in weld at U. T. S. of *83,600 lbs.,* per square inch, with an elongation in 1 in. of *23.6 per cent.* This result indicates that further improvements may be secured by heat treating as well as by the forging operation.

(K) Tool steel bars, ⅝x2 in., containing approximately 0.48 per cent carbon, 0.18 per cent vanadium, 1.0 per cent chromium, 0.85 per cent manganese were cut to a 60° vee and arc welded, employing a lime coated 3½ in. nickel steel electrode ⅛ in. in diameter with an arc current of 175 amperes. A welt of ⅛ in. was left on each surface. The joint and base metal were then forged on a No. 3 Nazel air hammer and quenched in oil from 875°C. The test piece, .408x1.625 in., failed twice outside the weld at a U. T. S. exceeding 88,900 pounds per square inch. This comparatively low value is attributed to residual stresses due to the quenching operation, subsequent welds were drawn.

(L) This weld was prepared in the same manner as weld "K," excepting welding current of 150 amperes was employed. After forging the joint was annealed from 900°C, to room temperature, then quenched at 875°C in oil, drawn at 250°C and surfaces machine-ground to a final section of .356x1.598 in. On

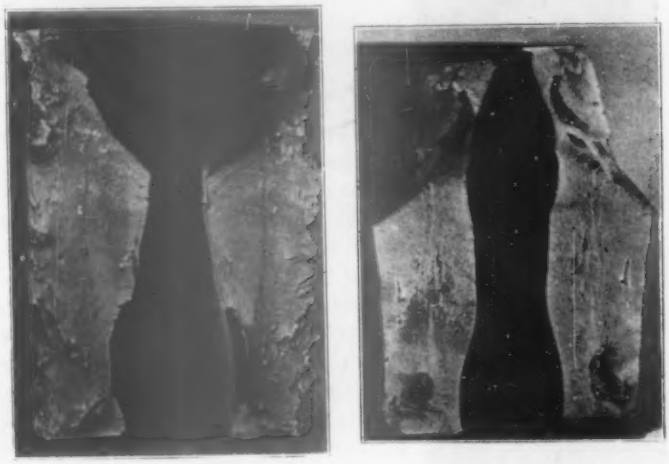

Fig. 11.
Silky, Fine Grained Surface of Fractured Welds, Fig. 9, and Fig. 10.

subjecting the joint to tensional load an ultimate tensile strength of *107,253 lbs.* per square inch; elongation in 1 in. of 14.4 per cent and reduction in area of 14.25 per cent was secured, the fracture occurring partly in the base and partly in the deposited metal. Figures 9 and 11 show the appearance of the fracture.

(M) This weld was prepared and treated in the same manner as weld "L," excepting that bare electrodes were used with an arc current of 175 amperes. The final section after forging, machining (to straighten), and grinding was 0.286x1.47 in. An ultimate tensile strength of 132,445 pounds per square inch was obtained with an elongation in 1 in. of 8.5 per cent and reduction in area of 5.6 per cent. This weld is shown in Figure 10 and the surface of the fractured section is shown in Figure 11.

These results clearly indicate the feasibility of producing alloy steel welds having a high order of strength and ductility providing a suitable deposition electrode is employed and the weld is subjected to adequate mechanical and heat treatments.

Fatigue Resistance

It is generally known that cast metals have low fatigue resisting properties as compared with metals that have been rolled or

TABLE IV
Accelerated Fatigue Test

	TOTAL STRESS CYCLES				Per
Material	*A*	*B*	*C*	*Avg.*	*Cent*
Base Metal, Mild Carbon O H. Plate	23,950	30,512	24,363	26,175	100
Cast arc metal, low carbon..	4,528	15,543	5,762	8,611	33
Forged* arc metal, low carbon	27,120	61,900	45,323	44,781	171
Forged** arc metal, low carbon	49,900	20,800	38,310	36,370	139

***Metal from test specimen No 5, Table III forged at* 1316°C.
**Metal from test specimen No. 3, Table III forged at* 1172°C.

(Continued on Page 40.)

FACTS*

FACTS in the literature of the oxy-acetylene industry have always been dodged in describing apparatus.

Anyone looking for data to enable him to make an intelligent and scientifically correct comparison between the various oxy-acetylene torches on the market has run against a stone wall in trying to find out what is meant by injector or semi-injector, positive or medium pressure, equal and balanced pressures, etc.

Instead of finding any real description of the principles of gas mixture he has, up to now, been able to find only *mechanical claims,* and unscientific discussions of the merits of this or that position of the valves, the desirability of lengthening or shortening the torch, the angle of the head; he has found nothing about the first requirement of a *real* torch—the principle of gas mixture.

This book of Facts is prepared to discuss thoroughly, the real points at issue.

Upon the *method* of bringing the gases together, the principle of gas mixture depends:

1st. *The Consumption of Oxygen*—whether the torch uses the correct volume or as much as twice that volume.

2nd. *The Elimination of the Costly and Annoying Flash-back.*

3rd. *Successful Steel Welding*—whether the weld is soft and ductile or hard and brittle.

4th. *The Quality of the Flame*—soft or harsh, melting and fusing or melting and blowing the metal from the line of welding.

5th. *Using All Gas from Both Cylinders.*

A torch may be *mechanically* right in every respect and *wrong* in every one of these five points. It may be beautiful to look upon; and the heart of it—the mixing chamber—entirely bad.

Because the oxy-acetylene process involves the use of gases, the man familiar with *mechanical* matters thinks it is difficult to grasp the *chemical* importance of proper gas mixture. Really this principle is simple.

An oxy-acetylene flame requires for its complete combustion 2½ volumes of oxygen for each volume of acetylene, of which *only 1 volume of oxygen should come from the cylinder,* and the remaining 1½ volumes from the air. In other words, *oxygen which you pay for* should be used in *exact* ratio with the acetylene—one part of oxygen for one part of acetylene.

It is entirely possible to attain this mixture in practice. Yet, it is a fact that measured from the cylinders, most torches consume anywhere from 20% to 100% more oxygen than equal volumes. Mechanical principles, of course, are important, but *the method of gas mixture is paramount.* A welding torch operated only two hours per day welding one-half-inch material, will in a year of 300 days, consume approximately 36,000 feet of acetylene. If the method of gas mixture is incorrect and it consumes 50% more oxygen than is required, you pay for 18,000 feet of oxygen which is thrown away, which at 1½ cents per foot, means a *direct loss of* $270.00, and an indirect one of considerable more—poorer welds, loss of time in flash-backs, etc.

To give a little time to the study of torch principles, then, is time well spent.

**Advertisement—Abstract from "Facts" Booklet.*

The construction of the first oxy-acetylene torch was not so much an invention as a development. Oxygen and hydrogen, as well as air and gas, had been used for many years to produce flames for soldering, and welding and brazing. In the case of city gas and air, the gas being under a very low pressure, it was necessary to use the air as an aspirating agent, exactly the same as is done today.

At that period (1901) acetylene was quite largely produced for house lighting purposes in what is known as low pressure generators. The development of the oxy-acetylene welding torch at that period naturally was along the line of harmony with the type of gas supply. Oxygen being compressed in steel cylinders to a high pressure and acetylene being manufactured in low pressure generators, *it was inevitable* that the early types of torches should take advantage of the oxygen pressure to aspirate or suck the necessary quantity of acetylene.

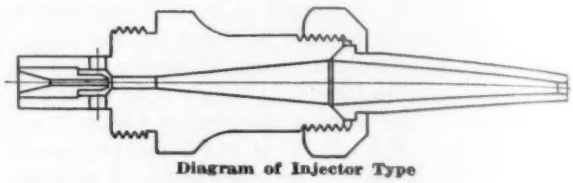

Diagram of Injector Type

Following the manufacture of the injector or low acetylene pressure torch came the type known as medium or positive acetylene pressure. By this time, generators were being manufactured which produced gas at a pressure not exceeding fifteen pounds and the positive pressure type torch took advantage of this pressure by somewhat reducing the oxygen pressure used as the aspirating agent. To illustrate this a little more clearly: a prominent injector type torch uses for a certain tip *35 pounds oxygen pressure.* For the same size orifice, the manufacturer of a positive pressure type gives the *oxygen pressure as 20 pounds and the acetylene as 6.* The principle of mixture, however, is very much the same with both types as both depend upon a high oxygen pressure to aspirate, syphon or suck wholly or partially the combustible gas.

To understand a little more clearly why constructors were *using oxygen under a high velocity* when the proper mixture required equal volumes of gases, it is necessary to know something about *flame propagation*—the speed at which a mixture of gases burns. Experiments had proven that a mixture of oxygen and acetylene would burn at a rate as fast as 330 feet per second, and with this knowledge, constructors of torches were using the oxygen to give to the mixture what *they thought* was a speed or flow greater than the speed of flame propagation with the idea, of course, that this would eliminate flash-back. It is a matter of history now that *this idea was erroneous.*

The development of the so-called equal pressure torch was perhaps primarily due to the tendency of torches using a higher oxygen pressure to consume more oxygen than the theoretical amount. It was necessary to place the mixing chamber of the equal pressure torch at considerable distance away from the burning or ignition point of the gases—that is the tip—*in order to prevent frequent flash-back.* Theoretically, the equal pressure type should consume approximately equal quantities of both gases, but for reasons other than gas mixture principles, this type of torch is open to objections. The mixing chamber is usually at the end of the handle, where it is difficult—if not impossible—to change the mixing chamber when the tips are changed—a vital consideration in torch construction.

In 1913 there was published "Autogenous Welding" by Granjon and Rosemberg, in French, and translated into English by Captain D. Richardson of England. This book is *the one* authority on oxy-acetylene welding and cutting and is so recognized the world over. In Chapter Six of this book, entitled "Oxy-Acetylene Blowpipes," appears this statement: "Of course with the oxygen being stored under great pressure it is always possible to obtain a high velocity through the nozzle, but for

reasons which it would take too long to explain here, the proper working of the blowpipe requires the oxygen under the most feeble pressure possible." Here is an authority *definitely stating that oxygen should be used under the lowest possible pressure.*

In the same chapter of "Autogenous Welding" is published a gas consumption test of various torches in which the *best* showing was 1.35 parts of oxygen—and the *worst* 1.90 parts—to 1 of acetylene. In other words, torches in this test consumed 35% to 90% more oxygen than the theoretical volumes of one to one. These were all low acetylene pressure or injector torches.

It was the REGO organization which proved that the rate of flame propagation varied— becoming *greater as oxygen was added to the* mixture and *less as it was taken away.* In other words, the higher the oxygen pressure at the point where the gases combine, the more likely—all other things being equal, would be the occurence of flash-backs, as a mixture containing a higher percentage of oxygen, burns with greater rapidity than does one containing equal volumes of the two gases, and a neutral faster than does one containing a higher percentage of acetylene.

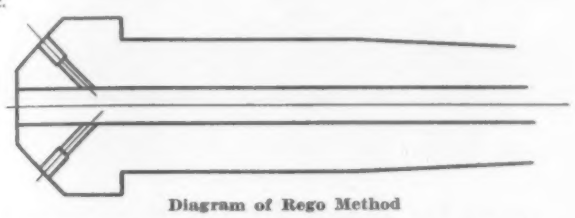

Diagram of Rego Method

The REGO principle of gas mixture *eliminates absolutely* any injector action. The parts carrying the acetylene and oxygen into the tip are so proportioned that *the oxygen inlet is the same size as the outlet* and the acetylene enters this oxygen inlet or mixing chamber at a pressure *ever so slightly greater* than the oxygen.

The REGO principle has been described as one of *higher acetylene pressure.* It could better be defined by stating that it is one *of lower oxygen pressure.* The acetylene pressure is practically no higher than any positive, medium, or equal pressure type, and considerably lower than many of them. The oxygen pressure, however, is materially reduced. On a tip size with hole somewhat larger than ⅛ inch the *maximum pressures* are 7 pounds of oxygen and 8½ pounds acetylene and this tip will operate perfectly in welding 1-inch steel plate at *one-half these pressures.*

It can quite readily be seen that this principle *prevents any excess oxygen from coming into the mixture.* The acetylene being slightly in excess in pressure dams or holds it back. In injector or semi-injector types the oxygen being largely in excess in pressure, the tendency must be and always is to use more than one volume of oxygen to one of acetylene.

Welding or cutting in confined spaces, bringing the tip in contact with molten metal, pressing it against a fire brick, overheating the mixing chamber—*none of these conditions will flash a* REGO.

The elimination of the flash-back not only means time and gas saved; it prevents any carbonized spots in the weld caused by carbon deposits when a torch flashes. When a flash-back occurs with other torches, the molten metal rapidly absorbs carbon from the incomplete combustion of the flame, as the gases burn inside the tip.

A truly neutral cone, *ideal for steel welding,* is produced, using exactly equal quantities of each gas. With this principle *there can be no free oxygen from the flame* to unite with the molten metal and form iron oxides, and to result in hard and brittle welds.

No laboratory test is required to prove these claims—any one-man job-shop has the necessary equipment to make tests as follows:

1st. *Consumption of Oxygen.* Weigh cylinder at start of good sized job and again weigh when finished. Figure 12 feet of oxygen to the pound and 14.5 feet of acetylene. REGO uses exactly equal quantities in cubic feet.

2nd. *Elimination of Flash-back*—plunge the tip into molten metal, draw it across wood, firebrick or cement or weld a hot, heavy casting—REGO does not flash back.

3rd. *Successful Steel Welding*—weld a section of boiler plate and test by bending in a vise to determine its ductility. While welding note the absence of excessive sparking—sparking is a certain indication of "burning" or oxidation—and freedom from froth.

"Sparking"—shows excess oxygen

4th. *Quality of the Flame*—The REGO—because of the very low pressures used—does not "blow" the metal from the line of welding. This is one of the most striking features to the operator, familiar with torches operating under high pressures, when he takes hold of a REGO for the first time.

5th. *Using All Gas from Both Cylinders.* The No. 10 tip of the REGO operates perfectly on 4 pounds acetylene and 3½ of oxygen. Many torches cease to operate with tips of this drill size when the pressure in the cylinders is four to five times as much.

With the REGO principle of gas mixture with its lower oxygen pressure, any danger of an explosion is eliminated. The acetylene cannot be driven into the oxygen line.

The largest REGO tip requires only 1½ pounds difference in the pressure of the two gases. It is *absolutely impossible* to drive the acetylene further than one inch back into the oxygen line (meaning that the mixed gases cannot go further back than the head). If the exit is plugged the acetylene shuts off the oxygen, and the REGO oxygen regulator immediately closes. As it takes about two pounds over the operating spring tension to bring the seat of the regular against the nozzle, the gases absolutely balance in pressure in the head of the torch; neither gas can go into the other line.

We have, in the foregoing, explained briefly, clearly and simply the great, outstanding merits of Rego apparatus. We have studied the character of the new oxy-acetylene flame; we have determined the true principle of the oxy-acetylene torch; we have described the building of Rego apparatus on the principle, calling attention to the many real advantages which follow. The logic of our proposition is irresistible.

To those for whom, perhaps, logic has no appeal, we say this: "Put a Rego outfit in your place and try it out for a week or ten days. Let it demonstrate that it will save you time and worry and gas and money; that it will make a better, cleaner weld; that it is the most economical, the best built, the most satisfactory in every way. We want your business; we want it on a basis of sheer merit. We know that in service REGO will prove itself.

THE BASTIAN-BLESSING COMPANY
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MALLEABLE IRON

Brookings, S. Dak.,
Friday, ...

Dear Ed:

I don't remember whether you were around that time when the gang was telling that story on Jimmie O'Neil or not. At any rate it happened about the year three B.P. (Before Prohitition). His highness Jimmie had been out celebrating and was returning home in the wee small hours as merry as a lark. Now Jimmie's house was surrounded by an expansive lawn and on the side nearest the walk was one lone tree. Jimmie avoided the concrete steps and started across the lawn, but he came in direct contact with the tree. He apologized, backed away and again started for the house, only to again connect with the tree. His third attempt was no better than the preceding ones so he resigned himself to his fate and sank down at the foot of the tree muttering, "Lost! Lost! In an impenetrable forest"—

That incident would never have happened to Jimmie if he lived in South Dakota, for the simple reason that they don't have any trees in this state. My friend, Andy, took me for a ride last night and it sure was a revelation to see so many miles and miles of perfectly flat prairie land with the wind causing the grain to roll in much the same fashion as the waves on a large body of water—but nary a tree in sight.

Andy is probably the best welder in this part of the country and I guess the boys all realize it for they come for miles to have him do their work. He's the fellow that started the welding course for the state college here so I was particularly anxious to see him and get his views on one or two things. Accordingly I journeyed down to his shop this afternoon but the air was so blue that I traveled right on without stopping and called him up on the 'phone a little later to make a date for this evening at the hotel. I didn't figure on his bringing Mrs. Andy along but it appears that he is scheduled to take her for a bit of a ride every evening so I was roped in too. When we got back to town we dropped the Mrs. at the house and Andy and I landed back at the hotel where I dug up a couple of smooth cigars and we chatted for several hours. Many points on welding were covered but I thought Andy's stand on malleable iron was just about right.

"Take these fool helpers that we have to break in," he said, "sometimes we calculate they just don't have any brains at all but I guess it's simply a question of how we look at things. We get sore because these younger fellows don't seem to use their heads and take such a while in getting hep to the right way of doing things, but perhaps if we looked back a bit and saw how long it took us to learn we would have more patience. On the surface though, if we tell them exactly how to go about a job and what will happen if it isn't done just that way you'd imagine anybody could do the thing right, but at that we're all kids more or less and we have to touch fire to find out that it burns."

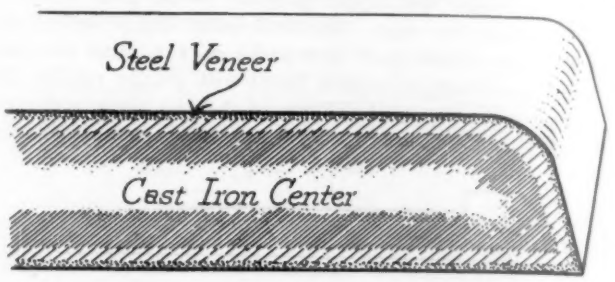
"That boy I'm breaking in now" he continued, "just about got my goat this afternoon. The shop was chuck full of work and one of the preheat jobs all waiting for me so I gave him a malleable job among others only to find out later that he had absolutely ruined it—For one of my best customers too"—

"How do you mean, he ruined it" I asked.

"Why he thought it was ordinary cast iron and proceeded to weld it with cast iron," Andy replied. "On some jobs it's pretty hard to tell a piece of malleable when you have it but there was no such excuse in this case; Zowie! it was so plain to see that it was malleable that even a blind man could tell it. And then to weld it with cast iron. Naturally it came out hard and brittle and if I let my customer have it, there is a possibility that it might hold together until he got it in place but that's about all, because there is considerable jarring on it and it would simply snap off. I haven't yet been able to dope out a way to make such a weld ductile and I never heard of anybody else doing so either excepting shooting it back to the foundry and have it annealled all over again. That's out of the question when you're away out here on the prairie."

"Maybe on those awfully particular jobs you ought to sort of stand by," I suggested as softly and sweetly as I could.

"Yes, I figure you're right and I generally do but this is one time my foot slipped. However, the water's over the wheel so we'll try to forget about it."



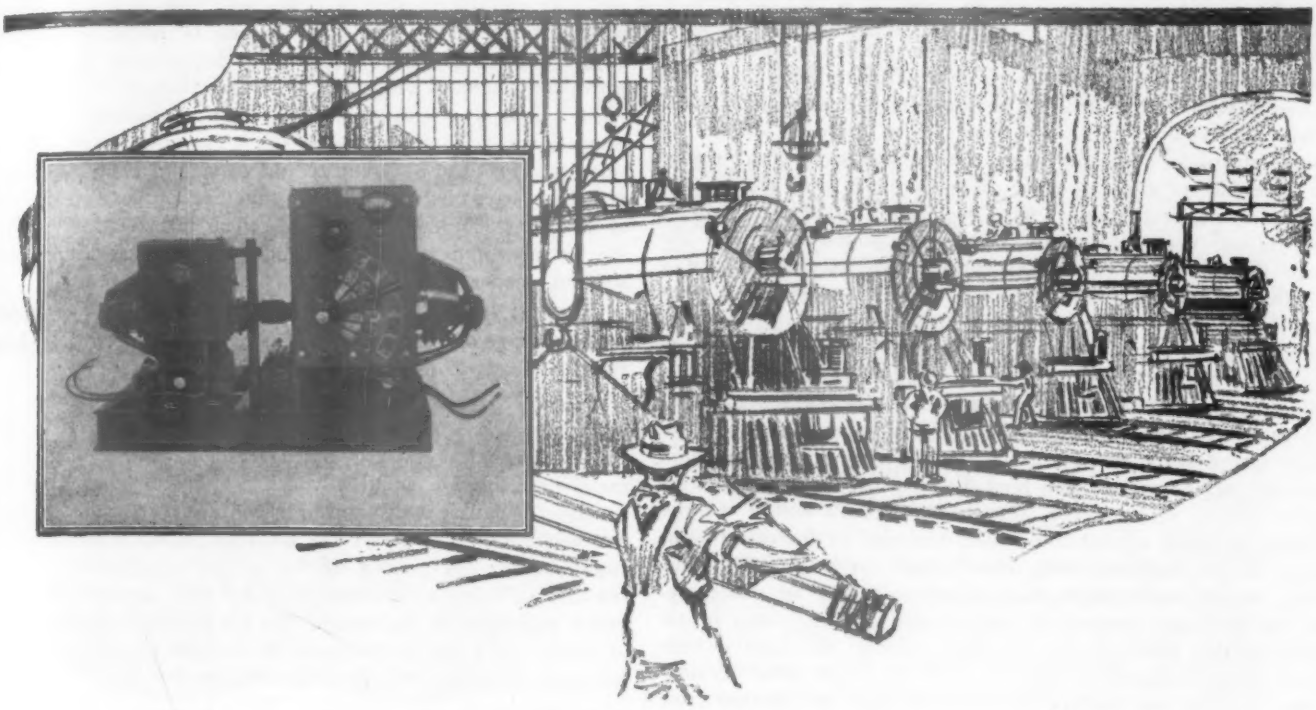
Cross-Section of Malleable Iron Casting.

"Evidently you consider malleable iron a pretty hard problem for the beginner," I said.

"Yes and no. If I may put it that way," he answered. "So far as I'm concerned I don't see how it is possible to melt malleable and have it come out malleable i.e.: ductile, because, as I've got it doped out it is poured in the foundry just as cast iron is poured then it's shot through an annealling process which absorbs much of the surface carbon and gives the casting, if broken, the appearance of having a veneer of steel. This is literally true and the longer the casting is left in the annealling ovens the thicker this veneer or skin grows. Now, since this is nothing more or less than a heat treatment, if we bring any part of the casting to a melting point, it is most certainly going to destroy the effects of the treatment in that locality and convert it right back to a brittle casting. A good welder will not melt his malleable iron any more than he would take a cold chisel, or any tempered tool, withdraw the temper and then expect it to perform as before. Consequently, if we can't melt malleable without destroying the heat treatment our next best bet is to braze it with a good tough bronze using plenty of brass flux. This makes a bond nearly as strong as the metal itself. In fact, it can be made even stronger if additional metal can be added, and at the same time it will come out just as ductile as the original if properly done."

"There is no trick to brazing; all you have to do is see that you have the proper heat. If there isn't enough heat your bronze won't flow; if too much it will boil in small globules on the surface and give off dense white fumes (zinc burning). An effort should be made to get the metal at a bright red heat where the bronze will run over the surface just like water. Many of the boys in starting get the right heat all right but not enough of it. By that I mean that the surface will heat up fast but it don't penetrate all the way through. Malleable castings as a rule are quite thin and it don't take but a few more minutes, if the torch flame is backed away a bit, before the heat goes all the way thru. The edges of the metal are better if not ground off, for the bronze has a better chance to adhere providing they are fairly clean and a good flux is used. A little oil or grease don't hurt because

If electric arc welding had been employed twenty years ago, the junk piles of manufacturers would not occupy valuable real estate today



Putting New Mileage Into Old Locomotives

Many broken or worn locomotive parts are being rebuilt and made as good as new through the use of electric arc welding. One railroad alone has replaced in service, with a *minimum delay*, several hundred locomotives—making repairs by this modern process.

This is one of the big applications of electric arc welding, but it is just as valuable in industries where the product is not so ponderous. Automobile parts, tanks, plumbing fixtures, metal furniture, doors, partitions, window sash, in fact many metal products which must be permanently joined—offer most profitable applications for electric arc welding.

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it's burnt off with the torch. Brazing is about the easiest thing a welder is called upon to do"—

"Then why all the furore over your helper?" I interrupted.

Andy took a good long drag on his cigar before answering and I could see a little twinkle came into his eyes. "The worst is yet to come, as you will presently learn," he answered. "As I have said, the brazing part is easy but it's the telling malleable iron when you see it that generally stumps the boys. Sometimes it's a pretty hard thing to do but with the rules I lay down here I can't see why they should go wrong. First of all let us figure out which metals it can be confused with. As I see it cast iron and cast steel are the only ones so you notice our field is somewhat narrow. If we know where the piece is used we will pretty near have the answer without any trouble because from observation I find that malleable castings are used where there is apt to be some strain, as a cheaper substitute for a drop forging. Going a little further along, a piece of malleable iron is always thin and doesn't weigh much. Fact is, I don't recall ever coming across any that weighed much over ten pounds. If there are any I'd call them exceptions rather than the rule. Next, a malleable casting seldom has any machined surface or parts subject to much wear for if the surface is removed the cast interior is exposed. When it comes to telling whether a piece is cast iron, malleable or steel, I read an article once that gave a few different methods and I've always remembered them. The first was the outside appearance. You see cast iron has a fairly smooth surface but generally some sand is in evidence no matter how long it's been used. Malleable iron as a rule is very smooth, free from all sand and it weighs about the same as cast iron. Steel castings on the other hand have rough surfaces with considerable sand appearing and they weigh much more than either cast iron or malleable. If the part was broken off and showed a fairly clean break then another method could be used, namely; the cross-section test. With malleable a ring or veneer of bright steel crystals show next to the surface while inside there are darker iron crystals. On steel and iron the cross sections are uniform all the way, but with steel the crystals are large, bright silver looking, while in iron they are fine and of a dark gray hue. Third came the test on the clean emery wheel. Malleable shows a few steel sparks and then iron sparks as the interior is reached. Steel gives off bright, luminous sparks that burst in falling, whereas iron has sort of a dull red spark that does not break as it leaves the wheel. After that followed the chisel test. When a cold chisel is applied to an edge of a malleable casting the surface will curl up until the interior is reached and then it breaks off. Now on steel you can keep on curling up as long as you have a mind to chip—but on cast iron your edge will chip right off. Last but by no means least comes the test with the torch. If a neutral flame is held on some corner of a malleable piece you can plainly see that a sort of skin appears on the surface and recedes before the flame giving off a few sparks and then large blowholes can be seen. Steel on the other hand gives forth bright sparks and the surface when melted appears nice and clear. Cast iron shows no sparks except where there are impurities. An outsider would almost think I was giving a lecture to a student the way I'm rambling on here but the point I'm trying to bring out is this;—after giving you a fair example of how us welders go about doping up a simple way to teach our helpers, so they'll stop wasting a lot of good gas and make themselves of some value, why won't they retain some of the stuff we tell them and not let it run off like water on a duck's back?"

I'm not going to tell you what I told him, Ed, or burden you with any more of Andy's grief but listen, Ed, I certainly hope that you aren't going to treat these letters in the same way that some of these helpers do. They're not the easiest thing in the world to write when a fellow's on the road so at any rate I'm hoping for the best.

I'm dead tired so its the downy cot for mine. Write me at Omaha.

Yours,

SHEP.

CLEANSING OF OIL FROM GAS CYLINDERS

Various members of the Compressed Gas Manufacturers' Association are now engaged in experiments in an effort to learn the most effective manner of cleansing compressed gas cylinders of oil, in order that such cylinders can be safely converted to oxygen use. Cylinders used for shipping gases made from petroleum products will naturally contain an oily sediment and other cylinders are very apt to contain oil passed over from compressors, testing equipment, etc. Therefore it is not considered safe to use cylinders for oxygen service after such cylinders have been used for another purpose until such cylinders are thoroughly cleansed. The investigations are for the purpose of determining the most effective cleansing agents and the manner of cleansing.

Following is a letter on this subject, from Mr. C. O. Epperson, Secretary of the Compressed Gas Corporation, to Mr. J. H. Hayes, Secretary of the Compressed Gas Manufacturers' Association.

"In accordance with my agreement with you I hand you herewith the chemical analysis of the residue of three gallons of carbon-tetrachloride solution which was used in washing out hydrogen cylinders which had previously been washed with gasoline and buck shot. After the washing process was completed, approximately 1½ gallons of the carbon tetrachloride solution remained. This was analyzed in two parts. Approximately one gallon was taken off the top and this top portion contained a sort of scum. The top portion and the bottom portion were then analyzed separately with the following results:

Carbon Tetrachloride	64.90%	98.00%
Iron as Iron Oxide	.17	Trace
Insoluble Matter (Sand)	.10	.05
Water	34.83	.45
Mineral	Trace	1.50

"It will be observed that the bottom part of the wash amounting to perhaps one-half gallon contained 1½% of mineral oil or approximately 1/16 of a pint.

Says Washing With Gasoline Is Not a Success

"This we take to be conclusive proof that the washing of hydrogen cylinders with gasoline of the ordinary commercial make is not a success from the standpoint of removing the oil contained, and in fact we think that the introduction of gasoline into the cylinder adds oil directly.

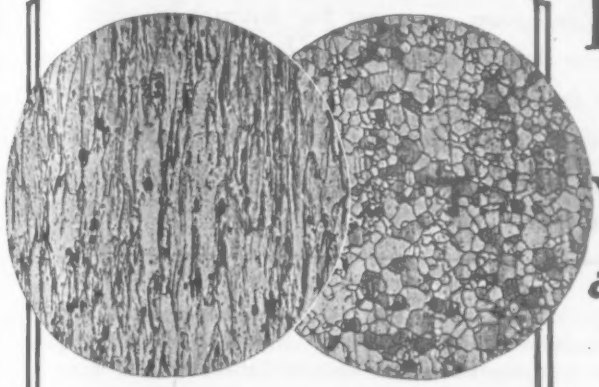
"To refresh your memory, the cylinders in question had been in hydrogen service and in order to transfer them to oxygen service, the cylinders were first steamed for several minutes under fairly high ressure and then washed out with gasoline and buck short. The chemical analysis above referred to is the analysis of the carbon tetrachloride solution that was used in those same cylinders following, although not immediately following, the gasoline bath.

"We are convinced that steaming cylinders at about 60 lbs. for five minutes, followed by a thorough cleansing with carbon tetrachloride, followed by another steaming removes every trace of oil and after such a cylinder has been thus treated, if it is completely filled with water and emptied, it is as safe to use for oxygen service as a new cylinder which has never been in hydrogen service."

Scientifically Controlled Heat Treatment

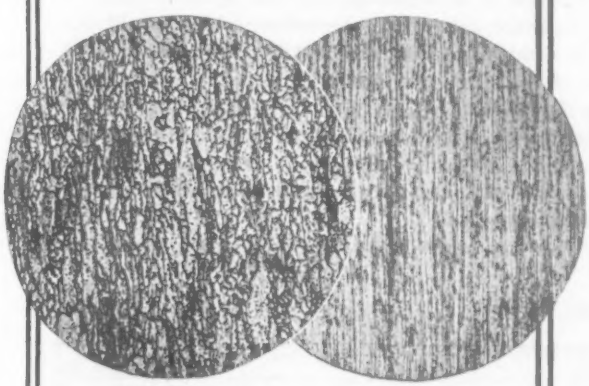
is essential to high grade

WELDING RODS and ELECTRODES



Photomicrograph showing grain structure due to improper annealing, typical of inferior gas welding rods.

PAGE-ARMCO Gas Welding Rods photomicrograph showing large grain structure due to proper annealing.



Photomicrograph showing grain structure of improperly annealed electrodes.

PAGE-ARMCO Electrodes photomicrograph showing elongated grains due to special heat treatment.

The appearance, "feel" or stiffness of a welding Rod or Electrode does not determine its welding qualities except to distinguish Gas Welding Rods (annealed) from Electrodes (hard drawn). The chemical properties and physical structure of the wire are the only safe guides to weldability.

In the manufacture of PAGE-ARMCO there is no guess-work, from the raw materials to the finished wire. PAGE-ARMCO Welding Rods and Electrodes are drawn from the purest iron ingot in the world—(99.87% iron) free from gas pockets, blow holes and other physical defects found in typical steel ingots. Then by scientifically controlled operations, one of the most important of which is heat treatment, the exact structure of the metal is produced for best welding practice.

PAGE-ARMCO Welding Rods and Electrodes fulfill all the requirements of the American Welding Society Specifications.

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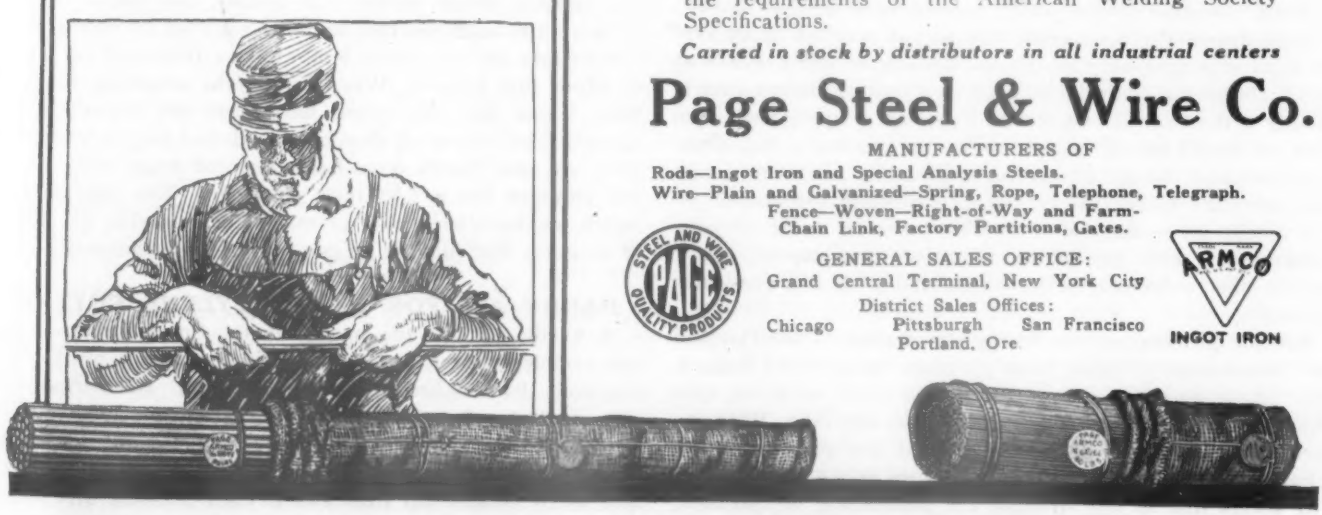
ARMCO INGOT IRON



PAGE-ARMCO
WELDING RODS and ELECTRODES

Hints for the Welder

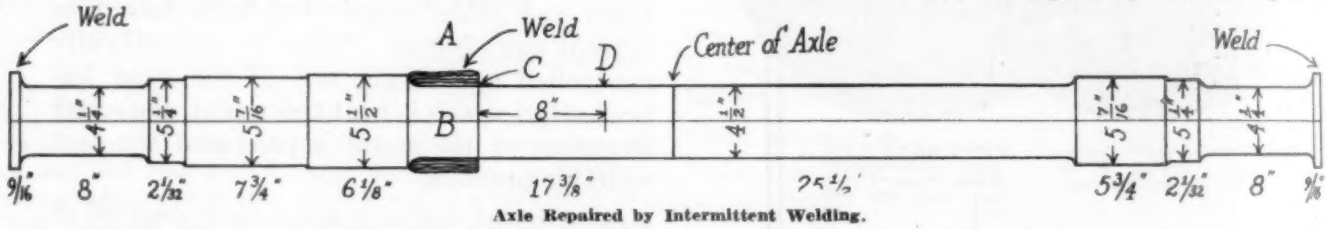
When you finish an interesting piece of work, can you set down on paper the manner in which you went about the job, how you prepared the work and how the job was done? Have you learned some little stunt every welder ought to know? Contributions to this department are paid for. Write it down any old way – I'll polish it up. Make a rough pencil sketch and our draughtsman will fix it up fine. Line drawings are more practical than photographs. Do it today – the men on the firing line are waiting. L. B. Mackenzie, Editor.

INTERMITTENT WELDING

By W. G. Owen

There are so many operations possible with the metallic arc, when used intermittently, that the field seems to be unlimited. Very often an operation is condemned because of internal stresses set up by the welding operation, which was a continuous one, and which, if done intermittently, would have been successful.

As I understand it, when a forged or rolled shaft is subjected to 600 degrees Fahrenheit there is a slipping of crystals which is purely a mechanical change, and which will revert to the original structure, provided the shaft is not quenched, but cooled naturally; but should the conduction of heat from the welding operation be such that the shaft is heated 1275 degrees Fahrenheit (690 degrees Centrigrade) there will take place a chemical change which will result in the setting up of stresses, and the consequent failure of the weld.



Axle Repaired by Intermittent Welding.

From the information which I have been able to gather, I have drawn the conclusion that to put a stress in an axle or shaft it is necessary to subject the axle or shaft to a heat at or above the critical point, as any change before that is simply a mechanical one which, if cooled properly, will take care of itself; but if heated above the critical point, there is a chemical change which has a tendency to revert to the cast structure as regards crystal or molecular formation.

I would invite discussion on this point by some of your contributors who are better informed than myself, as I should like to become better acquainted with this particular subject.

Putting into practice the theory stated above I have welded the button ends of axles, built up gears seats, wheel flanges, etc. These operations were intermittent, and so timed that one could lay his bare hand on the axle at any time. With the exception of a slight decarbonization at the point of fusion I found no change and no stresses set up in the axle.

It seems that in the struggle for production, or, perhaps, I might say, over-production, we lose sight of the fact that we sometimes destroy what we are trying to save. By attempting to work continuously with as near an unbroken arc as possible we have a conduction of heat that somewhere reaches a point where it sets up stresses, and though the weld may hold good for a while it will eventually give way on account of these stresses created by the continuous application of the arc. This is why I recommend intermittent welding for shafts, axles, wheel flanges, etc.

As regards the intermittent welding of cast iron, I have experimented with bearings, sectional heating boilers and cylinders with good results. Working on the theory that cast iron expands at 450 degrees Fahrenheit and using a certified metal, manufactured for the welding of cast iron, I have successfully welded cast iron parts without distortion by keeping the conduction of heat below the expansion point of 450 degrees Fahrenheit.

The field of intermittent welding is worth while investigating, as there are lots of operations which would prove a failure if welded continuously, but which can be welded successfully if the operation is intermittent. As an example, I mention the building up of rails. This operation should be intermittent with a nickel alloy rod, and not continuous, as the majority of the rail welds are at present. One will find that the metal will not fatigue and peel off if an intermittent operation is used.

A word as to the super-heating theory advanced by some for making ductile welds. If anyone can define the line between the super-heating and the burning of your deposit, I shall take my hat off to him. I have tried and am willing to admit that I can't. When I raise the amperage to superheat, I find that the excess heat burns my deposit, consequently I am worse off than before. I find that in tests made here our best results have been obtained when using 135 to 145 amperes for a 5-32 inch electrode. The only way in which we have been able to make ductile welds, or, rather, to increase the ductility of our welds, is by annealing.

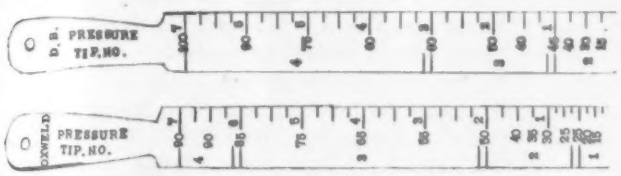
HANDY AID FOR OXY-ACETYLENE CUTTERS

A handy aid for the use of metal cutters who use the oxy-acetylene torch has been devised recently by K. McDermott, Steam Engineer and Assistant Mechanical Engineer of the South Chicago Works of the Illinois Steel Company. It is in the form of a nickel-plated hand rule about a foot long by 1⅛ inch wide and ⅛ inch thick, so graduated as to indicate tip sizes and oxygen pressure best suited to cutting steel sections of any thickness.

The Illinois Steel Company uses two different makes of torches—Oxweld and "D-B"—and, as a common scale would not apply to both, one side of the rule is graduated for the Oxweld and the other for "D-B," as shown in the illustrations. By a proper computation of scale a workman's rule can easily be made for any make of blowpipe. The manner of using the device is simplicity itself—you merely measure with it and instead of reading thickness in inches and fractions you read off tip size and pressure, thus render-

ing unnecessary any resort to memory or reference to a cutting table.

The new device is a timesaver and is a positive insurance against error and waste if the scale is read correctly—and in that respect it is as plain as anything could be. The idea is not patented. Any one can easily make his own cutting rule suited to the equipment used.



A Handy Device for the Gas Welder.

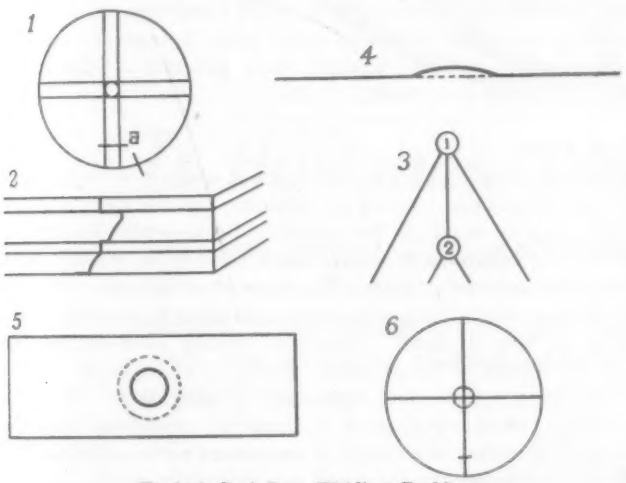
It may be noted, in passing, that the Illinois Steel Company is one of the country's large users of oxy-acetelyne, and that in both cutting and welding practice it has attained very high standards of efficiency. The Company's engineers have made a very thorough study of every application of the process that can be used to advantage in the mill and are utilizing it wherever possible because of its value in contributing to economy and speeding up of production.

CAST IRON WELDS

Fred W. Henricson*

In the November, 1920, issue of "Welding Engineer," under the heading, "Welding Without Pre-heating" I read some interesting things about how to weld a broken spoke in a cast iron wheel without pre-heating, by cutting the rim apart. (Fig. 1).

This idea no doubt worked out all right, as it would allow



Typical Cast Iron Welding Problems.

the spoke to expand and contract during welding, but suppose there was much more than one spoke broken, in which case the same procedure would have to be followed out for each spoke, and we all know that the less welded joints on the wheel, the better it is. With all respect for the writer, I think that such a way of doing a job is entirely unnecessary, which I will explain later.

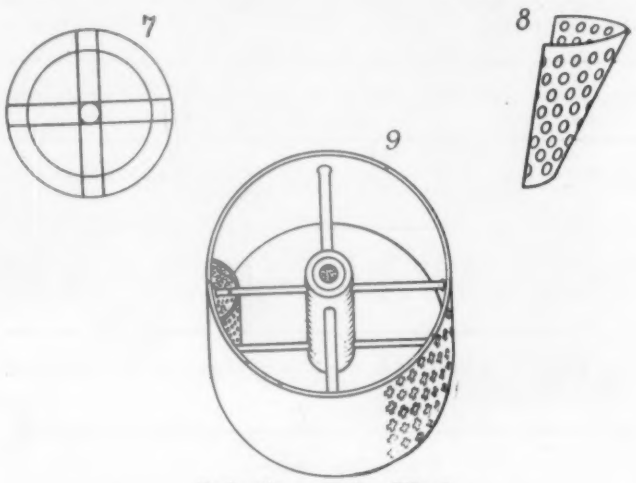
During the time that I have been connected with welding I have met many welders whose middle name ought to have been "Preheating" the way they always used that word, without the slightest idea as to the why and wherefore.

Many welders do not know what takes place when a job is getting heating before, and cooling off after the welding,—that is, to provide for expansion and contraction. If a welder, when confronted with a job stopped to consider the shape of it and the "go and come" of the metal, as I like to call it, he would often find that preheating of the whole job is often not necessary, and sometimes harmful. With each and every kind of a job there is a different way to start and finish. This rule does not pertain to cast metal only, but to all kinds of work. When considered in conjunction with cast metals, it generally means the prevention of cracking at the time of expansion in the beginning and the contraction when cooling off.

In welding up long sections of moldings, in form of cornices, say up to perhaps thirty inches wide, and in lengths up to 10′ 0″, two or three lengths joined into one, then the knowledge of the "go and come" becomes necessary, or you will have anything but straight lines. (Fig. 2.)

The same thing applies in welding angle mitres of large dimensions, so that they will be of the desired angle when cooled off. (Fig. 3.) Some welders seem to be under the impression that such jobs should be straightened after the welding is done by some other person, but that is wrong. If there is any straightening to be done, it should be done with the torch.

In conjunction with this statement of straightening with



Preheating a Pulley Wheel.

the torch, I will mention several ways of straightening that can be done. We will take, for instance, a large steel plate with a buckle in the middle. (Fig. 4.)

First we should know the cause of the buckle, before we are able to tell how to remove it. As most of you know, a buckle is caused by a surplus of material inside the circumference of the buckle, or in other words, more material than is necessary to form a straight line across. Hence the bent line, or, as we call it, a buckle. To remove this buckle with a hammer, we start at the edge of it and hammer all around, gradually going out to the edge of the sheet, stretching the same, thereby allowing the buckle to fall down. To remove the buckle in a quicker way, we now use the torch, and by putting a few red spots on the buckle we contract the surplus material, and the buckle will disappear. (Fig. 5.) Care should be taken in protecting the rest of the sheet by using wet rags.

In sheet metal boxes of light material we often find that they flap one way or the other and will not lie flat unless a weight is placed on them. The reason for this is that there is a strain across the metal from one side to the other. This can be relieved by pitting red spots with the torch all along the bottom edges. In doing this we are shrinking the outside circumference of the bottom, thereby relieving the strain. The box should be turned upside down and placed in a level position.

Welding of Spokes in Cast Iron Wheels

The general cause of the spokes cracking while the wheel is cooling off, after a preheated welding has been done, is that the spoke is contracting faster than the rim. In other words, the rim is not coming in fast enough. Therefore a strain develops in the spoke and it finally cracks. To prevent this, the

(Continued on Page 47.)

*With *David Lupton's Sons Co., Philadelphia.*

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Figures Have a Real Value.

COMPETITION stays right on the job after the customer is sold, so the user of welding apparatus is frequently urged to alter his practice or change his equipment. Sometimes the quality of the completed job is the main issue, but more often it is economy of operation, the solicitor quoting long combinations of figures to establish his case. Right there is where the solicitor strikes a snag. He is told that he goes too deep. The chances are that he isn't going deep at all. He shows very quickly that a saving of twenty-five cents per hour amounts to six hundred dollars per year. The computation is easy for him because he knows the answer before he starts. But that isn't going deep. It's just looking the facts in the face. A small saving on a single operation is not to be sneezed at, especially if the operation is repeated a great number of times in the course of a year; and the welder who doesn't consider the small savings is hurting himself as much as he would by doing small jobs without charge and trusting to the "big pieces" to make his business profitable.

Carelessness Feeds the Scrap Heap.

GIVE it time, and any piece of machinery will find its way to the scrap heap. Two similar pieces will probably not arrive at the same time, because one of them is sure to be sped on its junkward way by more careless and thoughtless handling. The welding torch is no exception. It seems to be a misunderstood piece of machinery; many operators do not realize that it is an instrument of precision, requiring care and consideration. A torch will not stand the same abuse that a sledge hammer will, yet it is often used as roughly. Poor supervision is largely to blame. The workman keeps a ten dollar micrometer gauge in a strong, plush-lined case, because he has been instructed that it is valuable and delicate. But he tosses an expensive welding torch carelessly on a bench, or under it, or into a box of loose tools, because he has not been properly warned against such practice. Somebody's sense of values is at fault.

Do It Right.

FAILURES are common occurrences when a welding process is crowded beyond its capacity, but the process itself usually has to stand all the criticism, because the man at the top who is ambitious to secure extra production doesn't want to criticize his own policies. The apparatus salesman can give the service man a heap of real co-operation by preaching the gospel of "Do it right," instead of waxing over-enthusiastic over the merits of his product. Doing it right is the all important thing. Speed is a secondary consideration. The service man's chief occupation is training operators, and he wouldn't be called in so often if customers were as thoroughly sold on the necessity for good workmanship as they are on the merits of apparatus.

Pocketing the Proceeds.

CASH dropped into the pocket is quickly forgotten and readily spent. There is no telling whether a business is making or losing money unless a careful check is kept on the receipts. An accurate cash record, showing where cash comes from and where it goes, is an absolute necessity to the man who wants to run his business on a firm basis instead of a guesswork basis. Putting the money where it can be watched enables the shop owner to locate leaks and to determine the relative values of cost items. Putting it in his pocket and spending it as the bills come in leaves him totally in the dark regarding things he ought to know.

Oxygen Regulator Investigation.

A SPECIAL committee of the Compressed Gas Manufacturers' Association is at work on the subject of oxygen regulator design and materials. In its initial conference the

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committee decided that the scope of its investigation should include a thorough bibliographical search in order that the present state of the art be known to all, an accumulation of the practical and experimental knowledge of the members of the association, and the comparison and testing of all types of regulators and their materials. Everyone interested in this subject can contribute to the success of the investigation by sending to the committee information, suggestions or questions.

CUTTING RIVETS AND SHIP PLATES WITH DXY-ACETYLENE TORCH

Two interesting repair jobs employing the oxy-acetylene torch were recently completed by McIntyre & Henderson, engineers, at the dry dock of Redman-Vane Marine Railway, Baltimore, Md.

On the first job the steamer "Corsica" (Fig. 1), rivet heads were sheared off with a combination cutting and welding torch,

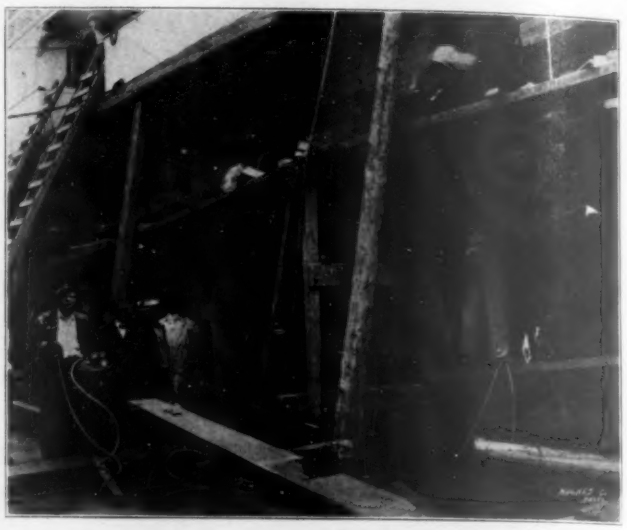
Cutting Steel Plates and Rivets on Bottom of Steamer.

in order to remove worn plates and replace new steel plates. Remarkably high production was attained, considering the time it took to locate rivet heads under the thick coating of paint and barnacles, and the care required to keep rivet holes in the O. K. plates intact to receive new rivets.

Cutting Bolt Holes Preparatory to Bolting on New Bottom.

On the other job, steamer "B. S. Ford" (Fig. 2), new wooden bottom was applied over the old steel bottom, without removing the steel plates. Bolt holes were cut at will through steel plates and frame with a combination cutting and welding torch. In some cases the cuts were through two thicknesses of plate and an angle iron.

Figure 3 shows a close-up view of the combination torch cutting one-inch cast iron beam. The engineers are well satisfied



Combination Welding and Cutting Torch Cutting 1-inch Cast Iron.

with these jobs, which demonstrated the practical utility of the combination cutting and welding torch for quickly cutting several thicknesses of plate, in many spots the metal being encrusted with scale and rust.

FORGING OF ARC DEPOSITED METAL AND ARC WELDS

(Continued from page 29.)

forged. It is, therefore, to be expected that the cast metal of arc welds would have a lower fatigue resisting value than that of the usual rolled plate or base metal which it joins. However, as proper mechanical working of the raw cast material is one of the recognized means for improving resistance to alternating stress, it should be obvious that cast arc metal should be similarly improved upon forging.

To obtain a rough measure of such improvement, accelerated alternating stress tests were made on specimens of forged and cast metal at a "nominal" stress of 31,000 lbs. per square inch in an Upton-Lewis fatigue testing machine. Each specimen tested had a section of 0.254x0.69 in. with a distance between jaws of ¼ in. The throw was adjusted to bring the calculated stress to approximately the same value in each case. (While in the writer's opinion, this calculated stress is considerably lower than the actual stress and cannot, therefore, be compared properly with static stress values, nevertheless, a fair basis is obtained for the determination of comparative performances of different material during rapid stress reversal.)

The Upton-Lewis machine places a bending load on the test specimen. This load is reversed every cycle. The machine was operated at a speed of 275 stress cycles per minute. Data obtained is recorded in Table IV. The actual stress, presumably greatly exceeded the elastic limit of the material, so that the total number of cycles in any case is quite small. However, the results are of value as indicating quite definitely that

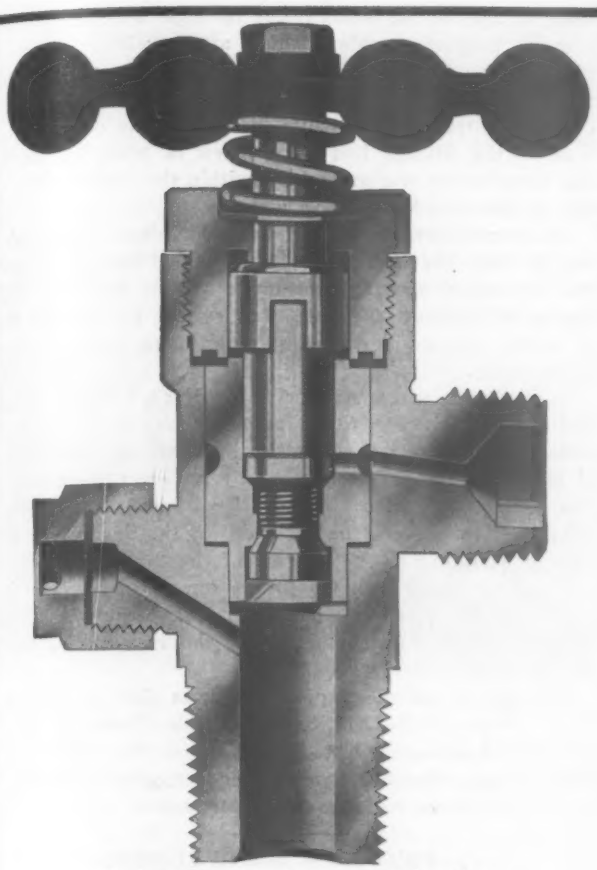
(1) The fatigue resisting property of cast low carbon arc deposited metal may be greatly improved by hammer forging.

(2) This property is influenced by the forging temperature and degree of mechanical work done.

(3) Hammer forged cast arc metal may be superior in fatigue resistance to mild carbon rolled plate.

SUMMARY:

While the scope of this investigation is too broad to permit of the exact evaluation of all of the factors considered, it, nevertheless, has been shown that



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Another thing, when you work out a successful solution to a welding problem write us about it. Grammar and composition don't count—it's ideas we want. If a sketch would illustrate your job in good shape, just make a rough pencil sketch; our draughtsman will do the rest.

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(1) Forging of low carbon arc deposited metal increases its elastic limit and yield point, as well as ultimate tensile strength.

(2) The ductility of arc deposited metal may be greatly increased by forging.

(3) If arc welded mild carbon open hearth steel is forged at the joint the joint will be stronger than the base metal.

(4) Resistance to alternating stress is improved by forging, so that the fatigue resistance of the arc metal is comparable to that of the plate.

(5) No inherent limitations to the development of arc welded joints having greater strength, ductility or fatigue resistance than those found in this investigation have been encountered. While the strongest weld reported had an ultimate tensile strength of 132,445 pounds per square inch and the most ductile arc deposit a reduction in area of 60 per cent there was no indication that these values could not be exceeded with a further study of the effect of mechanical and heat treating processes.

(6) It is possible to obtain alloy steel arc welds having physical properties comparable to those of the base metals.

* * * * * * * * * * *

The writer wishes to acknowledge his indebtedness to Messrs. F. P. Lauffer and Orr for assistance in the preparation and test of these welds.

NEW TYPE OF WELDED TRANSFORMER

The rigid requirements of the National Board of Fire Underwriters prohibiting the use in certain industries of oil-immersed, high-voltage transformers have brought about the development of a new type of transformer in the manufacture of which three gases—oxygen, nitrogen and helium—are utilized to a considerable extent.

Oxygen is used, together with acetylene, to produce a flame of sufficient temperature to weld the fittings of the transformer to the tank or case, as well as to weld the cover of the case to the case itself. Nitrogen and helium are mixed together in the properties of 30 per cent of the former and 70 per cent of the latter to form a gaseous dielectric which insulates and cools the transformer. This mixture is found to eliminate the hazard of fire.

In order to retain the gaseous mixture inside the transformer case it is necessary to make all the joints gas tight.

View of Completed Transformer.

Several experiments were made in order to determine the which welding process to use for this work, and as a result of these experiments the oxyacetylene flame was selected.

In the experiments with the oxyacetylene flame the fittings of the transformer were welded to the tank by the usual method of gas welding, the work being done by an expert welder of the Engineering Service Department of the Air Reduction Sales Co. The welds and the parts in the immediate vicinity of the welds inside the case were sand-blasted to remove magnetic scale formed after welding. This sand-blasting is a necessary precaution as the magnetic oxide is apt to work loose and fall on a part of the high voltage circuit of the transformer while the latter is in operation.

After the fittings had been fused in place by the flame, the transformer was assembled within the tank and the cover put in place ready to be welded.

An atmosphere of nitrogen was maintained in the tank during the time the cover was being welded in place to prevent the formation of magnetic oxide within the case. In the course of welding the case was cooled by a small stream of water running down its side near that part of the weld being made.

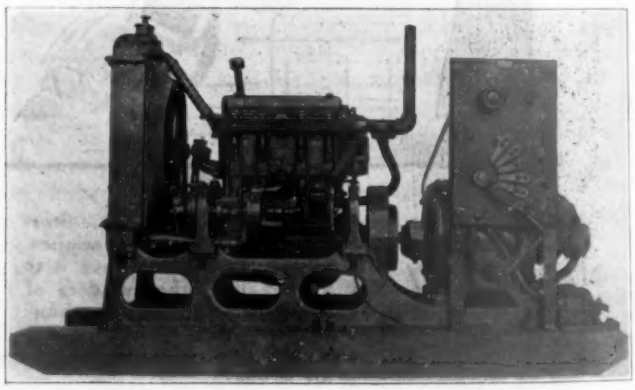
In instances where a poor fit occurred between the cover and the tank it was found advantageous to lay a piece of nickel wire in a tapered groove around the circumference of the straight portion of the cover. Then when the cover was pressed into place the nickel wire effected a sufficiently tight joint to prevent the "feather" of the oxyacetylene flame from penetrating to the interior of the tank.

In all the experiments with the oxyacetylene flame it was found that the torch could be used without any injury to any part of the transformer and that the resultant welds were gas-tight and entirely satisfactory.

The success of the experiments was due in a large part to the efforts of the Air Reduction Sales Company organization, which firm placed at the disposal of the electrical manufacturer the technical knowledge and experience of its Chemical and Engineering Service Departments.

TWO NEW G-E WELDERS

The General Electric Company has placed on the market two types of gas engine driven arc welding sets, one for medium, or intermittent duty, and the other for heavy duty. Both outfits are well adapted to industrial plants where the work to be done is located in odd places and is not sufficient to warrant the installation of permanent equipments. Their particular field, however, is in places where electric power is either unavailable, or inconvenient or costly to bring to it such as marine work, or for welding experts who own their own set, and travel about in localities where there is no electric power.

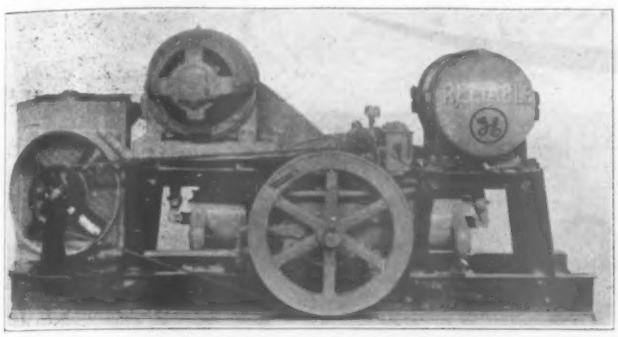


Constant Energy Arc Welding Generator.

The medium duty equipment was designed particularly for intermittent duty. The generating unit consists of a type WD 10-4 KW 1200 r.p.m., 60/20 volt 200 amp. generator directly connected by a flexible coupling to a Matthews, Model F., 4 cylinder, 4 cycle, 20 HP gasoline engine. The engine, radiator, generator, and welding panel are assembled on a rigid cast iron base, which in turn is mounted on wooden skids. The set is 86 inches long, 28 inches wide, and has a net weight of about 2000 lbs., making a light and compact affair to move about. The gas engine used with this outfit

has been especially adapted to the requirements of intermittent welding service. It is of the overhead valve type, the cylinders cast in block with the upper half of the crank case. The lubrication is a combination of splash and forced, and the cooling thermo-siphon, except where special conditions require the addition of a pump which is driven by the accessory shaft.

The generator is self-exciting and regulating, giving practically constant energy throughout the working range. It gives a no load, or striking voltage of 60 which automatically decreases to the proper welding voltage (usually 18 to 20 volts) when the arc is struck. It is driven by a speed at 1200 r.p.m.;



Gas Engine Driven Welding Set.

has a normal output of 4 KW and delivers a maximum working current of 200 amperes. The panel carries the generator field rheostat and series field dial switch by which the current can be adjusted from 200 to 75 amps. in 25 amp. steps. A reactor choke coil mounted on the set and connected in the welding circuit protects the generator from current surges.

The heavy duty equipment can be arranged to supply either one or two welding circuits. It consists ordinarily of a 20 HP. 2 cylinder opposed Reliable Heer, Model 00, gas engine, a type WD 9 generator and welding panel, the whole mounted on a welded structural steel base with a net weight of 2400 lb. for the single operator equipment and 3200 lb. for the double operator equipment.

The gas engine is designed for continuous operation at rated output. Careful balancing practically eliminates all vibration and the horizontal cylinder and relatively small flywheel make possible a compact assembly with the rest of the outfit. It will run on kerosene, distillate, gasoline, or natural or artificial gas, with a fuel consumption per brake HP not exceeding 1 pint of kerosene, distillate or gasoline, 10 to 12 cans of natural gas, or 17 to 22 ft. of average illuminating coal gas.

The generator is driven by a silent chain running in oil, and except for the speed its characteristics are similar to the WD 10 which forms part of the medium duty outfits. They run at 1750 r.p.m. instead of 1200 r.p.m. and differ somewhat in the windings because of the difference in speed and service requirements. An ammeter is mounted on the panel of each heavy duty equipment, but in other respects they are identical with those of the medium duty. A mere change of location, constitutes the only difference between the reactors of the two sets.

SAVING A 16-TON CASTING

In breaking up and remoulding a 16-ton casting, while the material loss would be negligible, the cost in labor and time would be considerable. The foundryman having to deal with a defective casting of such weight is deeply indebted to any process of treatment that can salvage it as originally cast. Since the development of oxy-acetylene welding a dependable means of salvage has been ready to hand in the form of the torch, and today no modern foundry is without some approved form of portable welding equipment. There are times, however, when the special training employed in the independent welding shop is requisitioned, as in the case to be noted.

The 16-ton casting instanced was recently salvaged by a job shop operator. It was a large punch press frame, part of which, when taken from the sand, proved defective. While not a particularly difficult job of welding, it was one of considerable magnitude, and presented a real problem to the foundrymen. It represented $1,800.00 worth of grey iron and labor.

On arriving at the foundry the operator found the casting honeycombed on one side over an area of 20 square inches and to a depth of 1¼ inches. Part of this section is clearly shown in Figure 1. On the opposite side (see Figure 2) it was necessary to build up and onto the casting a flange 2½ inches thick, 8 inches wide and four feet long.

Fortunately the character of the welds required only local preheating and their position was such that it was not necessary to move or turn the casting during the welding operations.

Two operators were employed and nearly 200 pounds of No. 9 cast iron rods were used as a filler. The job was completed to the entire satisfaction of all concerned in 12 hours of actual working time, while the cost represented but a very small fraction of the cost of duplication by recasting.

Figure 1.

Figure 2.

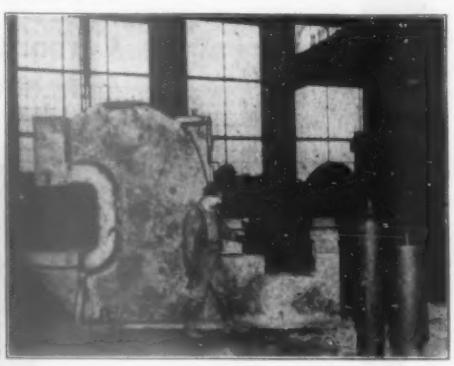


Figure 3.

The Superior Oxy-Acetylene Machine Co., Hamilton, Ohio, recently bought a three-story building at South Seventh and Walnut streets. This building will not be occupied immediately, but improvementt will be made in the present factory.

Announcement has been made of the organization of the Standard Safety Equipment Company, 168 N. Michigan avenue, Chicago, for the manufacture and distribution of safety equipment and supplies, as well as welding and cutting apparatus. The president of the new company is C. A. Kingsbury, formerly head of the Safety Department of F. A. Hardy & Co., Chicago.

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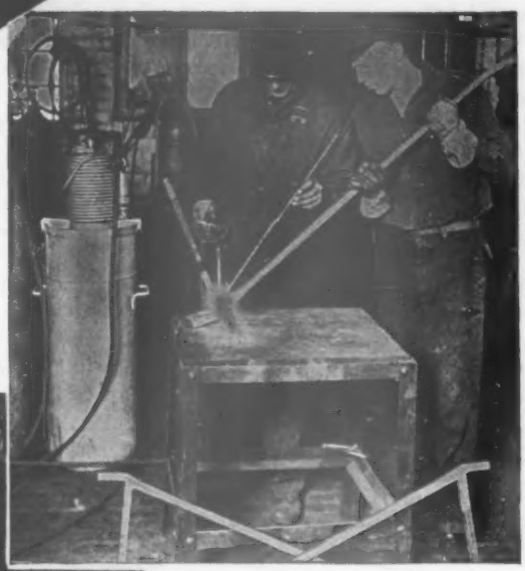

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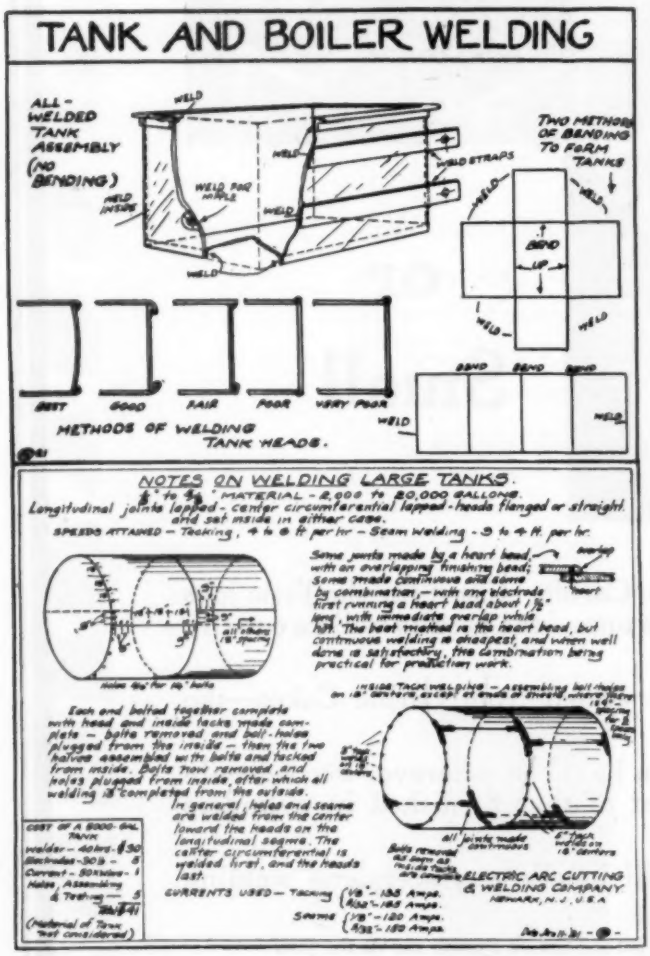
TANK AND BOILER WELDING*

A BOILER and tank shop is in general one that handles sheet metal from ⅛ in. up and arc welding is being applied more and more in these shops, replacing riveting on a cost, speed and workmanship basis. Arc welding is very alluring in this sort of a shop, as one man is a complete gang while riveting requires laying out, punching, fitting and a gang, the failure of anyone of which breaks up production.

While welding of high pressure heavy duty boilers is still in its infancy, the welding of boilers for medium pressure such as heating boilers, etc., has been an established business for several years, while the repairs to high pressure boilers are an every day occurrence on stationary, marine and locomotive work. These repairs consist of cracks and pieces set in, fire boxes, flue sheets, welding of flues, steam headers and other pressure parts so that the day of welding of the boiler itself openly and completely is very near. In the meanwhile the welding of tanks, vats, headers, flues and especially odd


TANK AND BOILER WELDING
ALL-WELDED TANK ASSEMBLY (NO BENDING)
TWO METHODS OF BENDING TO FORM TANKS
BEST
GOOD
FAIR
POOR
VERY POOR
METHODS OF WELDING TANK HEADS.
NOTES ON WELDING LARGE TANKS.
Longitudinal joints lapped - center circumferential lapped - heads flanged or straight and set inside in either case.
SPEEDS ATTAINED — Tacking, 4 to 6 ft. per hr — Steam Welding - 3 to 4 ft. per hr.
Each end bolted together complete with head and inside tacks made complete — bolts removed and bolt-holes plugged from the inside — heads then holted assembled with bolts and tacked from inside. Bolts now removed and holes plugged from inside, after which all welding is completed from the outside.
In general, holes and seams are welded from the center toward the heads on the longitudinal seams. The center circumferential is welded first, and the heads last.
ELECTRIC ARC CUTTING & WELDING COMPANY
NEWARK, N. J., U.S.A.

shaped parts or connections is being carried away by arc welding on the basis of merit and cost.

Either arc welding or gas welding can make a joint in tank work 100 per cent or over in strength, whereas riveting, even the best, cannot be much over 80 per cent and in general runs less than 60 per cent. Tightness of riveting is only made by caulking and a slight bang or blow will loosen up this tightness whereas in welding tests have been made deforming the tanks to a shapeless mass without starting a leak.

The illustrations show three methods of making rectilinear shapes; one well known method of cutting out and bending up and welding along the edges. This method is satisfactory for comparatively thin pieces, but fails where waste per square foot amounts to the saving and the cost of welding the bottom seam. The better method is shown below where there is no waste and only one edge welded. Of course the bottom has to be welded in separately but this is easily done as shown in the larger rectangular tank illustrated by setting it in slightly and welding from the outside.

The larger rectangular illustration shows a method of welding which is by far the best for any but quantity production, in which bottom, sides and ends are separate pieces; the bottom being the inside dimensions wanted and the sides being as much greater as the thickness of material used, the ends fitting in between the sides against the bottom.

The top, if one is required, can be neatly fastened by welding an angle inside or out and then fastening top with bolts or hinges. If tightness is required, even gas or air tightness, a shellaced cork gasket will give the required result. Where the thickness of this tank is small the edges can be bent over to form this angle and the corners chipped off round or welded out square. The holes for fitting in the top, sides or bottom can be cut by the arc after the tank is completed and fittings set at the desired angle and welded without danger of warping the fitting out of place or of warping the sheet into which it is set. This is an important feature of arc welding and the advantage of no warping due to a small amount of heat put into the plate shows up repeatedly in tank making. With arc welding the head can be put in dished or straight inside or outside and tacked in place. The weld can then be made with one or more heads continuously or in any sequence. Stay bolts if desired, can be welded in at any stage of the process that they are accessible without danger of pulling the head or sides out of shape.

With arc welding the welding can be made in any sequence best suited to the assembling of the completed article or the entire job can be tacked in place and welded as is most easy.

Either a rigid or non-rigid system of welding can be used; the rigid system consists of tacking everything in place solidly and the non-rigid proceeding in one direction, allowing the pieces to align themselves during the welding. The rigid system, in the author's opinion, is far better because it is easier and cheaper and gives equally good results if 100 per cent joints are aimed for, that is, if enough arc welded metal is added at the joints to more than equal the strain at those joints. To make sure if enough metal is added to more than equal the strength of the plates joined, no strains can ever be taken up by the welds. The strains and stresses in this case are transmitted to the rolled plate and the tanks or any structure made in this manner is by far the most reliable.

The weld made either by the gas or electric process is essential a steel casting and altho it is a good grade of steel casting, it can never equal the physical properties of the ductility and elongation of the plate which was a casting originally, but has been rolled and rerolled a good many times. The weld can be made rigidly, equal or greater in strength to the plate by adding a slightly greater section and in that case the strains even to permanent deformations are taken up by the plate more reliably than if the weld was made ductile in which case the bending, say, would be attracted to the joint, the welding joint being admittedly not the equal of a rolled plate to withstand such strains.

The weld, either electric or gas can be made about ¼ to ½ as ductile as plate by annealing and the gas process lends itself more readily to this annealing, but this annealing is a dangerous road to travel because of focusing the strains and stresses on the weld and because of spoiling the physical treatment by heating of the adjacent plates. The ultimate solution, in the writer's opinion is a comparatively cold arc weld which does not heat the adjacent metal appreciably and which makes a stiff strong joint, stiffer, say, than a double butt strap riveted joint and from one-half to twice the strength of such a joint.

Instruction from the handbook of the Electric Arc Cutting & Welding Co., 152 Jeliff Ave., Newark, N. J. Copies of the complete instruction book may be had from this company at $1.25 each.

Regarding the relative merits of butt welding and lapped welding the butt welding is ideal but there are many advantages in favor of the lapped weld, such as ease of assembly, not too fine accuracy in cutting and rolling and self-alignment of the seams when proceeding without special attention being paid to the rolled dimensions. These advantages, especially in starting production, as no special jigs are required, make the lapped weld the best general method for a boiler or a tank shop.

The laps, if made not too much and securely tacked on the inside make a joint stronger than the plate and it has been our experience that even the first large arc welded tank could be made cheaper than the riveted tank on which much experience had been obtained from production.

The larger illustration at the bottom shows the details and welding helps together with costs on such tans.

CAST IRON WELDS

(Continued from Page 37.)

spoke should be kept hot until the rim is well on the way of cooling.

In regard to preheating such a job, my suggestion is to heat only the part of the rim nearest the broken spoke. (Fig. 6.) By placing that part of the rim over the fire you will soon notice that the rim is expanding and the fracture becoming larger. Then do the welding, and immediately after you have finished remove the wheel from the fire and cover it. The contraction of the rim will amply take care of the contraction in the spoke.

Some time ago I was requested to go to a carpet mill to demonstrate, if possible, the proper way to weld the broken spokes in a carpet-printing drum. It so happened that the engineer of the plant had told the manager he could weld anything if they provided him with a gas welding outfit. I suppose that the salesman who sold the outfit said the same thing, and the engineer got his outfit; but he turned out to be on the level with the war time three weeks welding school experts, who are now so plentiful.

This printing drum was in the shape of a cast iron wheel 5′ 0″ in diameter and the rim 3′ 0″ wide with eight spokes, four on each side. (Fig. 7.) The outside of the rim, which was about 1″ thick, was covered with a ½″ copper plate, engraved with fancy patterns for color printing The spokes were cracked near the rim, and here, of course, preheating was out of the question, and to weld the spokes without taking care of the contraction after the welding would result in a sure failure. In fact, the engineer had already proved that.

The following is the way the job was done. The spokes were chipped out all the way through from one side only. A sheet metal basket was made in the shape of a cylinder (cone) cut in half from top down, with bottom to fit, and punched full of holes to insure draft. (Fig. 8.)

This contrivance, filled with charcoal, was placed inside and against the rim, under the cracked spoke, and the charcoal set on fire. (Fig. 9.) The spoke was wrapped in burlap from the hub to a point about 6″ from the fracture. A small stream of water was played on the burlap to keep the spoke cool. The idea of this was that the less expansion which occurred in the spoke the less contraction there would be to take care of; but whatever contraction occurred would have to be provided for. The fire in the basket against the rim was taking care of that. After the fire had been burning for some time the rim began to expand, the fracture in the spoke getting larger.

When the gap was well over $\frac{1}{16}$″ in width, the welding was started. As soon as the welding was completed, the fire was removed, also the burlap, and the spoke was wrapped in asbestos. The contraction of the rim prevented any strain in the spoke. The copper lining was only discolored from the heat, and the job proved a success.

ELECTRIC WELDED BLAST PIPE

The acompanying illustration shows an electrically welded blast pipe in the plant of the Keystone Bronze Company of Pittsburgh. The pipe was made by the Electric Welding Service Company of Pittsburgh, using Armco Ingot Iron sheets and Armco Welding wire. This pipe is to furnish air

View of Electric Welded Blast Pipe.

to ten blast furnaces for melting copper and bronze and two Turbo air compressors, having one pound pressure are used to furnish 5,400 cubic feet of air per minute. The pipe is buried in the ground and subject to severe corrosive action.

ANYTHING BUT A BROKEN HEART

If your heart is broken don't expect too much of the U. S. Welding & Machine Co., of Miami, Fla. As will be noted by a glance at the picture, this company explicitly sidesteps the welding of broken hearts. But anything else—well, the broken heart is the only exception.

If you want a welded tank or need a speedy repair on broken

One Job They Won't Try.

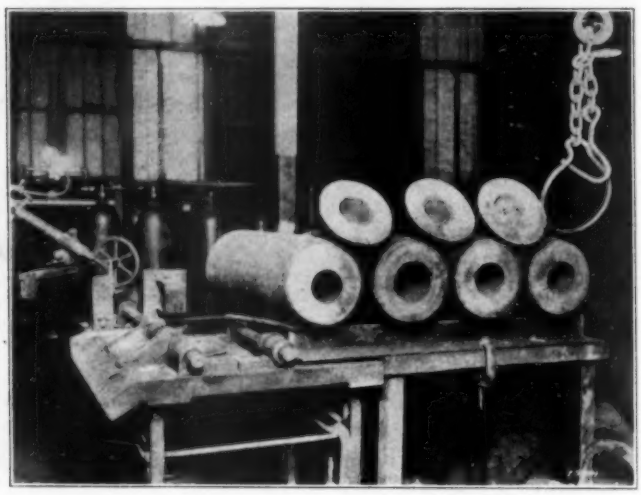
machinery, all right. That kind of work is pie for the U. S. W. & M.

The float shown in the picture was a feature of Miami's annual Palm Fete last December. The process the company employs is indicated by the acetylene tank and oxygen cylinder and by an oxy-acetylene torch held by the welder at the left center in the photo.

SHELLS MADE INTO CYLINDERS

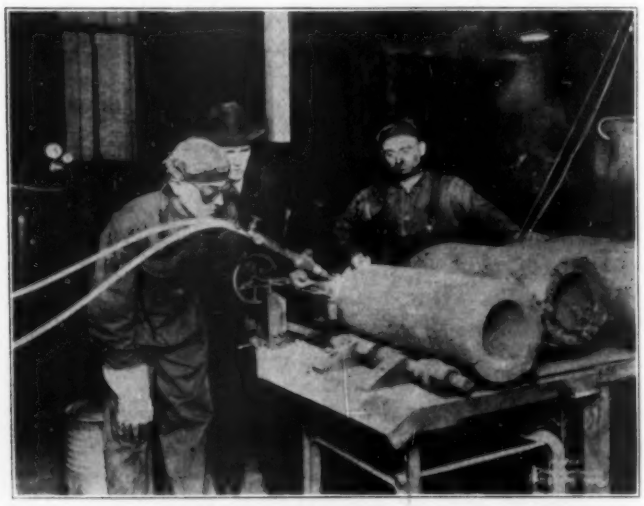
When the armistice ended the world war the belligerents were left with surplus munitions of various kinds, including enormous stores of shells for army and naval guns. In this country vast quantities of shells are now being returned to industry as raw material in the form of scrap to be charged with the melt in the steel furnace.

An interesting exception, in which shells of a certain caliber are converted to use as semi-finished material without melting and subsequent moulding, rolling or forging, is afforded



The Torch Cuts the Ends Cleanly.

in the oil well equipment industry. In at least one instance an Oklahoma manufacturer of oil well machinery and supplies bought 9.3-inch naval shells for use in turning a special type of metal fitting. All that was necessary to adapt the shells to the finishing operation in the lathe was the removal of the solid ends or noses with the oxy-acetylene cutting torch,



The Shells Are Revolved Under the Torch.

which left the bodies or explosive charge sections in the form of cylinders having almost the exact dimensions and form desired. The finishing in the lathe was then a comparatively simple and inexpensive operation.

The mode of executing the oxy-acetylene cutting operation is of unusual interest. Owing to the considerable bulk of the shells, which were 3.93 inches in diameter with a wall thickness of 2½ inches and a total weight of 375 pounds, and also to the large number (approximately a thousand) that were handled, a special jig was rigged for holding the work and a heavy-duty machine cutting torch was used. The method of handling them through the cutting operation was as follows:

Each shell was lifted by a pneumatic hoist to a platform just in front of the jig and placed in the correct position for cutting. The jig was designed to admit of revolving the shells by hand at the required speed under the cutting flame. The part of the jig holding the blowpipe was similar in construction to the corresponding part of a straight line cutting machine, the torch being held firmly in a clamp and so arranged that it could be easily moved horizontally or longitudinally as required. Thus the shell, when seated on the jig was automatically in the correct position for revolving under the cutting flame. To assure a uniform and even cut, the shell was first punctured about an inch toward the head away from the line of cut, when the flame was carried through the metal to a point selected for beginning rotation of the shell, the cutting then proceeded until the severed end dropped.

The entire operation from the time the shell was in position on the jig until the cut was completed, occupied only three minutes. The jig was so designed that after each cut the cylinder end remaining on the table could be dumped by means of a simple trip, when the succeeding shell could be mounted immediately for cutting.

The illustrations give a good idea of the jig and hoisting clamps and show very clearly the cleanness of the cuts as effected with the special apparatus employed. After the salvaging of the cylindrical bodies the solid ends were disposed of as scrap.

MOREHEAD ESTATE OFFERS GOLD MEDAL

The estate of the late Major J. Turner Morehead has set aside a fund to provide an annual income of $100, which they offer to the International Acetylene Association to provide at each convention a medal to be given as a memorial to this pioneer in the calcium carbide art.

The association has had a diploma designed and an attractive die made, from which one medal will be stamped for each convention. This medal will be awarded for the best paper presented at each convention. The term "paper" includes reports of committees, papers read before the association, speeches delivered, etc.

Any person taking part in the programme of the convention will be eligible, whether a member of the association or an invited guest, and whether an American or a foreigner, appearing in person or sending a paper to be read by proxy.

At each convention a committee will be appointed who will consider the papers, speeches, reports, etc., delivered at that convention.

They will report their findings to the officers, prior to the succeeding meeting of the association, and the officers will have the medal and diploma engraved with the name of the recipient, and these will be presented at the following convention."

The Oxweld Acetylene Company of Newark, N. J., announce the removal of the offices of their Foreign Sales Department from Newark to No. 30 East 42nd street, New York, N. Y. In this new location the company will maintain a greatly enlarged and completely equipped organization for foreign trade. Separate departments for Sales, Engineering, Advertising, Shipping and Accounting have been established, each in charge of a competent man of long experience in the export field.

A new welding plant, the Central Welding Co., has started operations at 1005 Twelfth street, Canton, Ohio. The president and general manager, Glenn E. Wilson, was formerly with the Oxweld Acetylene Company at Chicago.

PROCEEDINGS *of the* AMERICAN WELDING SOCIETY

33 West 39th Street, New York

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PRODUCTION WELDING WITH THE GAS FLAME*

By R. D. MALM†

THE rapid progress made in gas welding in the past ten years and the wide application it has found in industry is a subject too broad to cover in detail in the time allotted to me so I will confine my remarks to the machine welding of steel products.

The advent of gas welding has gone down in industrial history as a memorable event which marked the resurrection from the scrap heap of much valuable equipment which could not be restored to service by any process known to industry previously. And, for a considerable period of time application of the art of gas-welding was confined to reclamation work and job welding on a small scale.

But industrial leaders soon saw the possibilities of the process in production work and hand welding was adopted as a standard method of fabricating metal parts.

In due course hand welding yielded to the trend of the times and efforts were made to supplant the slow manual operations with automatic machinery.

The early gas-welding machines were built for the production of iron and steel pipe of heavy gauge and usually were equipped with a pre-heating furnace in which the formed material was preheated prior to welding.

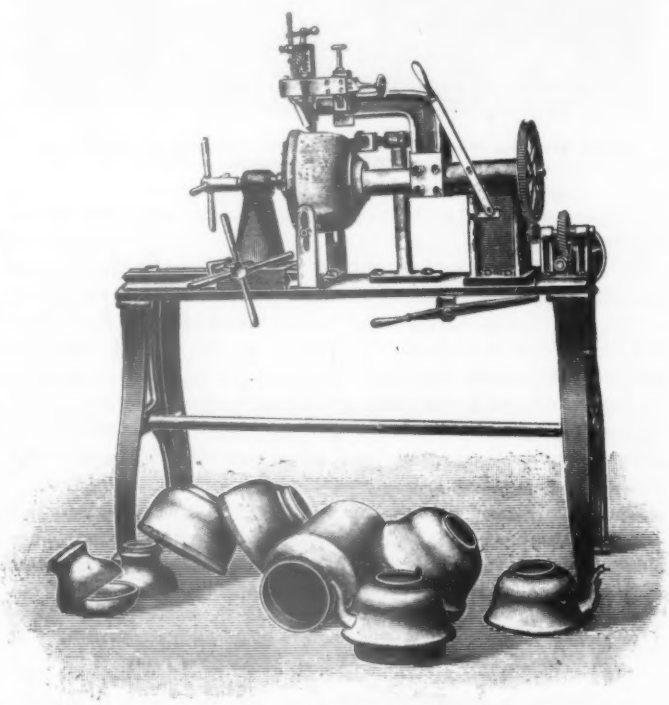
After leaving the furnace the pipe passed through vertical rolls which fed the stock up to a pair of horizontal pressure rolls at which point the seam was welded without the addition of a filler by passing under a stationary welding torch which melted the two edges of the stock together as they were being held in contact by the pressure rolls.

The preheating furnace was advantageous from purely a welding standpoint, but there were so many disadvantages from the production standpoint that it was discarded; hence, the present day machines in general utilize a special water-cooled multiple jet torch to do both preheating and welding with the same tip, although in some processes independent flames are provided to preheat ahead of the welding flame,—some designers going even so far as to operate a preheating torch on the underside of the seam in cases where the dimensions of the article to be welded will permit.

This type of machine can be used to weld long lengths of tubular shaped stock such as round, oval, square, rectangular and also the more complex sections such as are used for windshield frames, etc., in which the stock is of constant cross section throughout its length.

The welding of barrels, housings, tapered tubes and other articles in which the cross section is variable, presents a different problem, since these cannot pass through rolls as in the case of round tubing.

Two types of machines have been designed to handle this class of work, the one comprising stationary metal dies over which the welding torch is propelled along the seam, and the other a stationary torch under which the stock clamped in moving dies travels forward under the flame.



Circular Seam Welding Machine.

A machine of the stationary-die type can be readily built from an old lathe by placing welding dies on each side of the lathe parallel with the bed and with the welding torch supported on a swinging arm attached to the lathe carriage.

In this manner the torch will travel forward over one die the length of the weld and is then swung to the opposite side of the lathe where stock has been placed in the dies preparatory to welding. By reversing the travel of the carriage, the torch will

*Paper read before the annual meeting of the American Welding Society in New York, April 29, 1921.

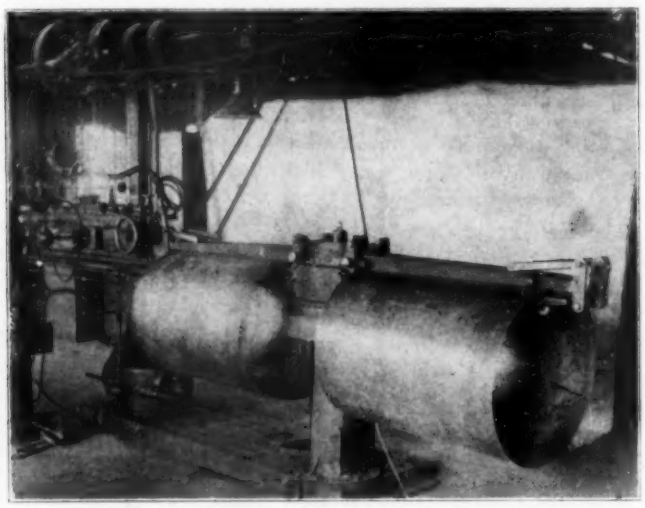
†Supt. Tube Dept., Standard Parts Co., Cleveland, Ohio.

move back over the second die completing the weld while stock is being replaced in the first die for a repetition of the welding operation, and so the cycle continues.

This type of machine has the widest application of any and the length of the article welded is governed solely by the travel of the carriage.

The torch is secured in an adjustable holder which permits of movement in three planes; hence the operator can easily regulate the movement of the torch along an irregular seam.

The cost of welding dies is comparatively low and dies can be replaced for a new job with little delay and at a small expense. However, where large quantity production is dealt with on a standard article and the size of the piece to be



Barrel Welding Machine. Barrel Is Held Stationary and Torch Moves Along the Seam.

welded is not too great, a moving die machine will prove very economical.

Here the welding dies, either one piece or sectional, are mounted on two parallel chains which are driven by sprockets at one end of the machine and pass around idlers at the other end. One operator feeds the pieces to be welded into the dies as they move forward. The second operator regulates the torch and welds the work as it progresses under the torch. The welded articles are released from the dies as the chain passes around the sprocket and drop into a truck ready to be moved on to subsequent operations.

The welding of seams on circular, square or polygonal shaped containers can be accomplished by rotating the work under the welding torch either vertically or horizontally depending upon the location of the seam.

Stock up to ¼ in. in thickness can be welded in these seam-welding machines without the addition of a filler.

This in general is a brief description of the various types of seam welders in use today and gives the principles of operation of each, although they will differ in detail according to the peculiar problems encountered in the various jobs.

Many modifications of the various types of welders have been built, as for example, a tube welder in which the forming, welding, sizing, grinding, straightening and cutting operations have all been combined in one automatic machine, but since the welding is done in the same manner as we have described we will not attempt to go into further mechanical details of each at this time.

The next problem after deciding upon the proper type of welding machine is the determination of the most suitable material from which to manufacture the article.

From a welding standpoint the best commercial steel is open hearth, either hot or cold rolled, with the following chemical analysis:

Carbon	.05 to .15
Phosphorus, not above	.045
Sulphur " "	.050
Manganese	.30 to .60

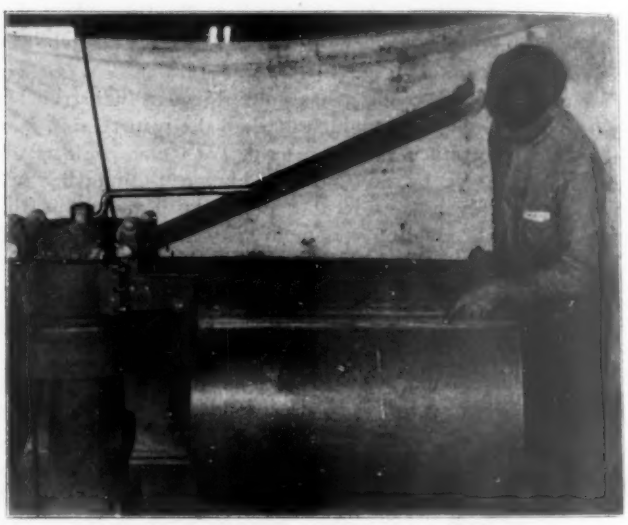
(This analysis is the same as the S.A.E. specification No. 1010 for carbon steel.)

The steel should be free from segregated crystallation, laminations, slivers, cracks, pipe flaws, slag or oxide inclusions and other injurious defects.

The surface and edges of the stock should be free from lime, rust and dirt which will form slag inclusions in the weld and decrease the cohesion of the metal as well as retard the action of the welding flame.

The above specifications can be revised to get higher carbon and manganese contents when required in the article to be welded, but the sulphur which causes the most trouble in the welding operation, should never exceed .050 or you will encounter "hot short" metal which will not flow readily under the flame.

The chemical and physical properties of the steel must be maintained at a high degree of uniformity since any appreciable variation will have a great effect upon the welding qualities of the material, as for instance, a high carbon steel will become burnt if subjected to the heat required for low carbon and a light gauge tube will melt through under



Steel Barrel Being Removed from Welding Clamps. Showing Welded Seam.

the action of a flame, which is proper for heavy gauge stock.

We have considered at some length the types of welding machines and their application in the industry as well as look into the material we are to work with.

Let us now start with our raw material and follow it step by step to the finished stages in one of the processes we have been discussing.

The most important application of steam-welding, as well as the most interesting in my opinion is the tube-welding process.

Here, our stock is received from the mills either in coils of variable length depending on the gauge and width of stock, or in flat strips of suitable length for handling in shipping, or else in mill sheets. If the stock is received in sheets, these must be cut into strips of desired width by passing through slitting rolls prior to the forming operation.

Strip stock is usually received from the mills slit to width, but if not, this stock too, should be trimmed to desired width to remove the selvage or round natural edge which will not produce a uniform high-grade weld.

This stock of proper width is run through a continuous rolling machine consisting of several pairs of gear driven com-

panion rolls of such design as to gradually form the stock from a flat strip to an open seam tube. These flat strips which have been cut to proper length prior to entering the forming rolls pass through the tube-forming machine at a speed of from 50 to 150 feet per minute depending upon the size and gauge of the stock and come out uniform in cross section and with a straight seam, both of which conditions are essential to good welding.

The open-seam tube is placed in a trough in front of a seam-welding machine equipped with a pair of vertical rolls which propel the tube forward at a comparatively slow speed under the stationary welding torch and through the pressure rolls where the weld is completed.

A stationary guide blade riding between the edges of the tube prevents the seam from twisting and getting out of line with the welding flame. After leaving the pressure rolls, the hot tubing passes into a pair of sizing rolls which restores it to proper cross section. Here water is poured on the tubing to cool it prior to the straightening operation which takes place in the final pair of rolls.

Our tubing is now welded and straightened and sufficiently true in diameter and smooth in finish for many purposes for which it can now be cut to length and fabricated or shipped as straight tube.

If further refinement of finish is desired, the tubing can be polished on an emery coated felt or canvas wheel to remove the slight excess of metal left along the seam and then be sized in a rotary swaging machine.

A single size of welded tubing can be drawn to any number of smaller sizes and various shapes by first annealing to refine the grain of the steel and then passing thru dies or rolls on a drawbench.

The weld that has been produced in this process is a combination of steel casting and compression weld and unless refined, will not have as good physical properties as the original metal. As the abutting edges of the tube come under the influence of the welding flame, the upper surface of the stock is heated to the fusing point and a puddle of molten metal is formed while the lower portion not in direct contact with the flame has received sufficient heat by conduction through the metal to become plastic or, in other words, is at a welding heat.

The pressure exerted by the pressure rolls completes the weld by forcing together the edges of the stock now plastic and the result is a compression weld on the underside and a fusion weld on top.

When you consider that the majority of gas-welded tubing is manufactured from stock $\frac{1}{32}$ in. to $\frac{1}{8}$ in. in thickness it is evident that very close regulation of the heat is necessary to produce a perfect weld.

If a single jet torch is used for welding it becomes necessary to raise the temperature of the metal 2600 deg. F., or in other words, from room temperature to the melting point of steel, in a fractional part of a second while on the other hand if several jets are acting upon the stock as in the case of the multiple-jet torch, the metal will be preheated gradually up to the proper temperature and the lower section of the steel will be allowed sufficient time to reach a plastic stage.

On a given gauge of tubing the faster the welding speed desired the greater number of jets required, and the greater the distance between jets to obtain maximum economy in the welding flame.

The tendency toward high speed welding in the past few years has resulted in much bad welding due to the fact that the necessary concentration of the heat was so great to obtain proper penetration that the upper surface of the steel was burned by the time the lower section had reached a welding heat or else the upper section was properly fused and the lower portion never reached a welding heat and resulted in what is known in shop practice as a "cold weld" or "sweat weld."

A machine welding torch requires for its operation a larger volume of oxygen in relation to acetylene than is the case with a hand welding torch, due to the inability of the flame to derive as large a percentage of its oxygen from the air while burning in a confined space between dies or rolls where there is not a free circulation of air.

The chemical reaction for the complete combustion of acetylene is as follows:

$$2(C_2H_2)+5(O_2)=4(CO_2)+2(H_20)$$

Here we see that it requires 2½ parts of oxygen to one of acetylene for the complete reaction. But, in the welding flame this reaction takes place in three stages:

No. 1. $2(C_2H_2)+2(O_2)=2(H_2)+4(CO)$

No. 2. $2(H_2)+4(CO)+2(O_2)=2(H_2)+4(CO_2)$

No. 3. $2(H_2)+4(CO_2)+(O_2)=2(H_2O)+4(CO_2)$

In a hand torch one part of oxygen is mixed with one part of acetylene in the torch and reaction No. 1 takes place at the tip of the first cone of the welding flame.

Reactions No. 2 and No. 3 should obtain oxygen from the surrounding air as the torch is moved about in the hand welding operation.

However, since the machine torch is either stationary or operating in a confined space where air currents are more or less obstructed it is necessary to furnish 1¼ to 2 parts of oxygen to one part of acetylene for proper torch operation.

This excess of oxygen is detrimental to the weld as the free oxygen will strike against the heated metal and cause oxidation. This can be remedied to a large degree by inducing air currents around the welding flame in such a manner as to feed the flame without too great a cooling action.

There are many other combustible gases that are used for welding purposes and I have used acetylene for illustration here since it is most commonly used.

The efficiency of the welding process is a subject that few regard very seriously in production work so long as the workmanship turned out is of good quality but when you consider the waste that can occur through improper design of equipment, condition of the welding gases or the low thermal efficiency of the welding flame in practice you will readily see the necessity of extensive tests to determine best conditions for oprating.

Tests should be conducted to determine the length of seam welded per unit of gas consumed and also the ratio of oxygen to acetylene under each different condition of operating and from these the best can be adopted.

You will find that by having the jets very close together a large percentage of the heat is dissipated by radiation while if the jets are too far apart the conduction of heat away from the seam by the adjacent metal will cut down the thermal efficiency of the flame materially, so it is necessary to strike the proper balance of the number of jets, the spacing of the same and the welding speed for a given condition.

If the ratio of oxygen to acetylene indicates an excessive consumption of oxygen it is necessary either to remove the obstructions that are cutting off the air currents or else supply air to the flame by induced draft.

Moisture in the gases will reduce the heat of the flame as well as cause the flame to sputter due to condensation of the moisture in the water-cooled tip, but this can be remedied by passing the gases through suitable driers.

Dust and dirt should be removed by passing the gases through filters to prevent the dirt from clogging the passages in torches and regulators.

The gas welded tube industry has in the past five years outdistanced all its rivals in the production of light gauge steel tubing and millions of dollars have been invested in tube welding plants, some of which have a capacity of several million feet per month.

This tubing combines light weight, strength and smooth finish with a relatively low production cost and has found a wide use in the manufacture of automobiles, bicycles, motorcycles, furniture, munitions, aeroplanes, go-carts, conduits, tools farm implements gas engines, conveyers and an almost endless list of articles in the construction of which tubular steel parts are required.

The manufacture of gas welded tubing has advanced in a very few years from a small specialty line to a vast industry serving so extensive a field of manufacture that I would weary you with its description.

Manufacturers in the past have fostered a spirit of secretiveness regarding gas weld production work and are likened unto the servant in the parable who buried the talents for fear that they be stolen from him instead of allowing them to increase in value through use, to his own enrichment and the benefit of others.

We pride ourselves in some of the achievements in production welding on steel products but the possibilities for the future in welding the other commercial metals in a similar manner are limited only by the skill and imagination of those conversant with the industry.

ANNUAL FALL MEETING

The annual fall meeting of the American Welding Society will be held at Philadelphia, during the week commencing October 17th. In addition to the technical sessions, provisions are being made for meetings of the American Bureau of Welding, and of its research committees, and of the Directors of the Society.

ELECTRICIAN USES ACETYLENE ON INTERESTING MOTOR ALTERATION

Occasions when it is desirable to convert an electric motor from one phase to another are not of infrequent occurrence. It often happens that a second-hand motor can be obtained at a bargain, and that, while it is satisfactory in other respects, it requires alteration to suit the power service where it is to be installed; or, where plant equipment is removed to a new location, the available power may be such that a change of phase in motor to suit existing power conditions can be effected in less time and at a lower cost than would be involved in obtaining a motor of the desired phase and wattage. In either case it is cheaper to fit the motor to the power than to change the service where power is already installed.

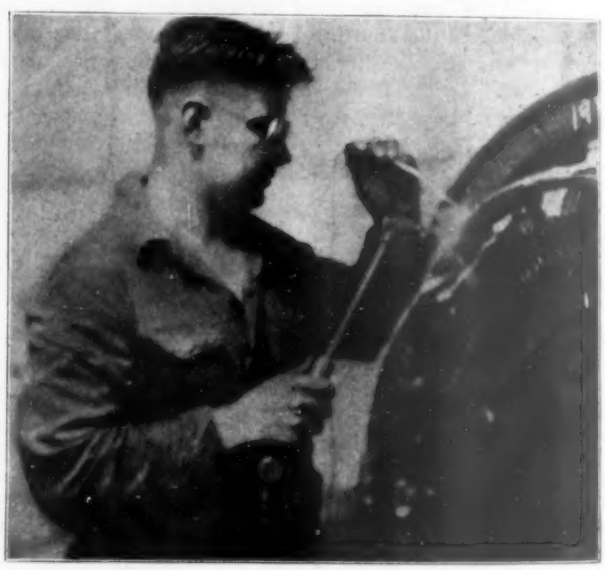
Conversion of the multiple-phase motor to meet an altered condition of power is, however, a rather "particular" job, and anything that simplifies the operation is of interest to electricians. The old practice of using a gasoline torch for removing, tinning and soldering "jumpers" has never been entirely satsfactory, owing to the intricacy of the closely assembled parts of motors, which makes it difficult to manipulate the gasoline flame without injuring or destroying insulation on conductors adjacent to the connections that have to be soldered. This disadvantage appears to be overcome by the use of acetylene, according to a New York electrician, who claims that the flexibility of the acetylene flame, and the ease with which it can be controlled and applied, not only greatly reduces the danger of "mussing the job" but speeds up the work.

This electrician has just completed the conversion of a 200-hp. motor (valued at $4,000 from three phase to two phase for the general laboratories of the Union Carbide and Carbon Corporation, Long Island City. The motor had previously been in service in the plant of the American Everyday Company just across the street from the laboratories, but that short move was enough to link it up with an entirely different service condition necessitating the alteration noted. In effecting the change of phase it was necessary to remove 172 jumpers, tin the ends and solder them into new positions, involving 1,032 separate operations with the blowpipe, that is, the melting off, tinning and re-soldering of 344 connections.

On this particular job an emergency outfit consisting of a small oxy-acetylene torch was used, just the tip of the long finger of fire being applied to the work. The conversion was completed in less than a week and at a cost under $200.

The Converted Motor.

The oxy-acetylene torch, however, while it performs the work satisfactorily, is not necessary, as sufficient heat and the same advantages it possesses over the gasoline torch are available in the air-acetylene torch, such as is used by telephone companies in making electrical connections. The air-acetylene torch, however, has advantages of its own in being lighter, in being adapted to use with a small tank of acetylene, in not requiring either oxygen or compressed air in a cylinder or service line, and in its greater consequent economy and convenience. Its portability (the complete outfit, including torch, hose and acetylene tank) is such that the operator can easily



Acetylene Proves Cheaper Than Gasoline.

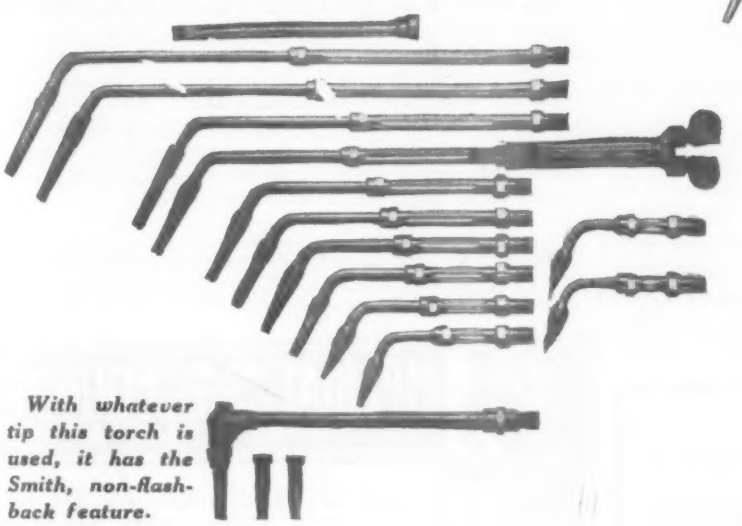
carry it from place to place without a truck and work in any quarter where connections have to be made.

The electrician in charge of the work described states that the applicability of acetylene to soldering in difficult places and the speed made with the torch proved so satisfying that he has ordered its use in sweating on approximately 5,000 lugs and in making other electrical connections in the laboratories. He estimates that the work can be done with acetylene in less than half the time necessary to handle it with the gasoline torch. He adds that unskilled labor readily picks up the work with acetylene and can be safely detailed on soldering connections when told where to make them.

The SMITH Line of Welding Torches

The success of the Smith torches is due to the fact that they possess distinctive features embodied in no other torches. They are also backed up by a reliable guarantee. In shops the country over they have enabled less skillful operators to do better work, and highly increased the abilities of skillful operators.

Smith's No. 6 Heavy Duty Torch



With whatever tip this torch is used, it has the Smith, non-flash-back feature.

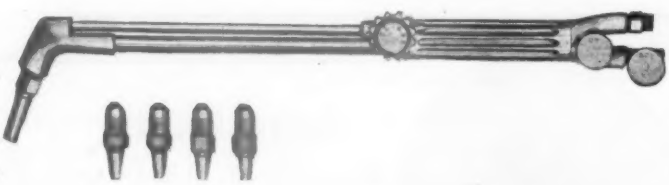
This welding torch is designed to meet the requirements of the most exacting work. It has a tip to fit any kind of work at hand. The torch has a fluted grip, is well balanced, and is surprisingly light and easy to handle in spite of the heavy work which it is designed to do.

The welding tip may be replaced with a cutting tip and in a few seconds the welding torch is transformed into a cutting torch that will cut steel up to 6″ thick.

Smith's No. 4 Pistol-Grip Welding Torch

Note the oxygen valve right under your thumb, where you can adjust the flame as you work.

This economical, easily operated torch may be instantly changed into a cutting torch by changing tips. It stands up under severe use.



Smith's No. 15 Cutting Torch

This torch is hard to beat for cutting special shapes, risers on castings, sheets, steel work, etc. The cutting jet valve is within easy finger reach, enabling the operator to do finest work without throwing the head out of line.

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Wanted—Representative to sell our full line of welding supplies on commission basis. Write for territory. Address 93, care The Welding Engineer.

Position Wanted—Oxy-acetylene welder with six years' experience would like to connect with firm as foreman or instructor of welding. Best references. Address 94, care The Welding Engineer.

For Sale—Up to date electric welding plant; must be sold to settle family interests. Portable gas driven unit mounted on motor truck. Stationary unit easily transportable; can be used almost anywhere. Acetylene outfit and all necessary tools with well equipped shop. All large plants within sixty miles from shop are patronizing this business. Address, Unit Electric Welding Co., 119 Carpenter St., Reading, Pa. 4t—July-Oct.

Position Wanted—Acetylene welder with twelve years' experience in job shop work. Now employed as foreman of shop having six welders. Address 95, care The Welding Engineer.

Welder Wanted—Large job welding and tank manufacturing company in Ohio wants experienced oxy-acetylene and electric welder, capable of handling men. Also salesman familiar with welding for soliciting repair work, etc. Both must be willing to make small stock investment. Give references and details. Address 96, care The Welding Engineer.

For Sale—REPAIR BOAT, equipped with complete Electric Welding Outfit, Air Compressor Tank Forge, etc.; 100 H. P. Boiler. All in fine working order. An ideal plant for repair work on vessels.
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2t—July-Aug.

Wanted—Second hand oxygen cylinders. Give complete history, specifications, location and price. Address 97, care The Welding Engineer.

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Wanted to Buy—Service agreements or ownership of 100 ft. acetylene tanks. Address 100, care The Welding Engineer.

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Because many of the readers of *The Welding Engineer* are interested in the Automotive industry the publisher of *The Welding Engineer* has pleasure in announcing *The Automotive Electrical Engineer,* a new monthly publication which will be devoted exclusively to Starting, Lighting and Ignition.

The field of Starting, Lighting and Ignition, so far as the transmission of direct information is concerned, has been in something like the same position as the frontier settlement—dependent upon "cross-lot avenues" of communication.

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In the past, the Starting, Lighting and Ignition problems of the service station man, the electrical equipment man and the garage mechanic have been treated by many of the leading Automobile trade journals of this country with beneficial results. The time has arrived, however, when this branch of Automotive Engineering has reached a point where no one of the existing trade papers can devote sufficient space to Starting, Lighting and Ignition topics to keep the interested reader fully advised on these subjects. In other words, Starting, Lighting and Ignition is a specialized field and a specialized trade paper is needed.

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Current Welding Literature

THE DESIRABILITY OF STANDARDIZATION IN THE TESTING OF WELDS, by F. M. Farmer—Published by the Institution of Mechanical Engineers, London, England. The paper presented to the Institution by Mr. Farmer, is practically the same as Technical Bulletin No. 1, published by the American Welding Society, on "Standards for Testing Welds." In reproducing it the Institution has included many interesting excerpts from discussions by the leading English authorities on welding.

THE POSSIBILITIES OF FUSION WELDING, by A. S. Kinsey—The possibilities of a good fusion weld depend upon high tensile strength, ductility, density, control of welders and a proper method of testing welds.—Acetylene Journal, August.

USE AND MISUSE OF ACETYLENE TANKS, by David Baxter—Acetylene Journal, August.

ALTERNARC—Booklet published by the Electric Arc Cutting & Welding Co., Newark, N. J. Contains particulars of portable cutting and welding machines, electrodes, supplies and accessories, and a list of parts of vessels that have been welded by this process. There is also some detailed information of the use of arc welding in foundries, machine shops and motor factories.

REGO CATALOGUE NO. 23—Published by the Bastian-Blessing Company, Chicago, Ill. A complete catalogue of the Rego line of cutting and welding torches, regulators, adapters, fittings, and welding and cutting outfits. An interesting feature of the catalog is an illustrated index in the first part, which refers the reader to the torch page and the outfit page on which various models can be found.

ELECTRIC ARC WELDING IN RAILROAD SHOPS, by A. M. Candy—An explanation of the characteristics of arc deposited metal and some examples of arc welding on locomotives.—Railway Mechanical Engineer, July.

SPEEDING UP BOILER REPAIRS BY THE USE OF AUTOGENOUS WELDING PROCESSES, by C. E. Lester—Savings in time by use of welding; preparing new sheets; operations formerly necessary; defective flue sheets.—The Boiler Maker, July.

BRAZING WITH THE WELDING TORCH, by David Baxter—American Blacksmith, Auto and Tractor Shop, June.

SUCCESSFUL USE OF WELDED JOINTS IN BALTIMORE, by W. W. Wysor—By staggering the welds on seam welded street rail joints, instead of carrying the welds across the entire width of the joint plate, the percentage of broken joints has been greatly reduced.—Electric Railway Journal, July 30.

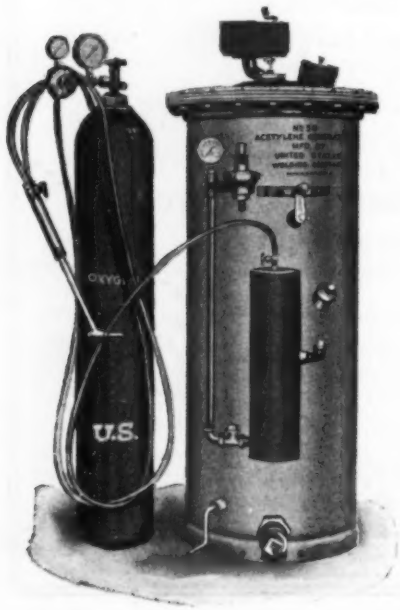
THE USE OF WELDING IN RECLAMATION, by F. S. Tinder—Description of the reclamation work done by the Virginia Railway Company at Princeton, Va. Repair of a cast steel tender frame. Reclaiming car couplers. Building up worn pistons, frogs and switch points.—Railway Purchases and Stores, August.

EXPANSION AND CONTRACTION, by D. Richardson—In cylinder, pipe, and tube welding there are two kinds of distortion to contend with: longitudinal distortion due to diminuation in length of the line of welding; and circumferential distortion due to transverse contraction of the molten bath tending to straighten the plates in the vicinity of the weld. To overcome the distortion of the circumference it is recommended that the metal be hammered into an oval shape so that after welding the contraction will bring it back to a circular shape. Spreading the sheet before welding will prevent the longitudinal distortion.—Acetylene and Welding Journal, July.

ELECTRICALLY WELDED MOTORSHIP ESAB IV, by Oscar Kjellberg—In order to gain experience in the application of electric arc welding to shipbuilding and to test the utility of the regulations for welding issued by Lloyds and other classification societies, the board of directors of the Electric Welding Company, Ltd., of Gothenburg, Sweden, is building a 50-foot boat in which welding will be substituted for riveting. Although the experimental vessel is of small dimensions, the form is such as to introduce a number of large flat plates with a view to obtaining information relative to the efficiency of welding for the flat bottom and sides usually found in modern steamships.—Marine Engineering, August.

The International Acetylene Association have decided to hold their annual meeting and convention on October 4th, 5th and 6th at the Hotel Commodore, New York City.

The Cincinnati offices of the Lincoln Electric Company have been removed from 810 Mercantile Library Building to 32 E. Front street, where they will occupy a four-story office and warehouse building.



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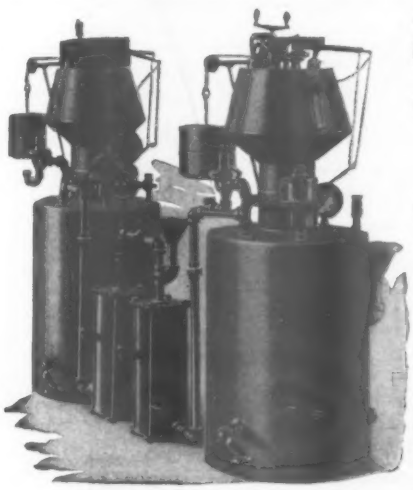

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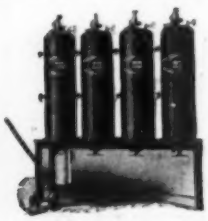
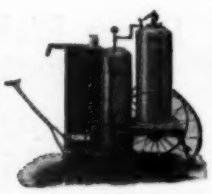
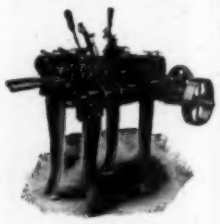

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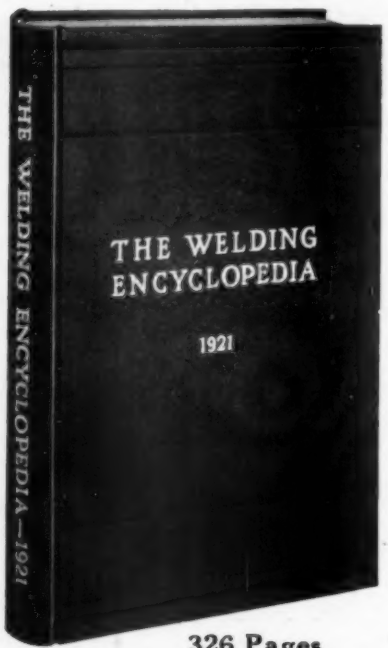

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